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Quaternary Micromolluscan Fuana of the Mudlump Province, Mississippi River Delta.

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QUATERNARY MICROMOLLUSCAN FAUNA OF THE MUDLUMP PROVINCE, MISSISSIPPI RIVER DELTA

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
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James X. Corgan
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ABSTRACT

A micromollusk is defined as a member of a superfamilial or higher taxon in which representative species are less than 6 mm in maximum dimension and there is strong evidence of a phyletic trend toward smallness. Sixty-five micromolluscan species are recorded from Quaternary clays of the Mudlump Province, Mississippi River Delta.

Forty-four new taxa are formally described. Forty-one of these occur in mudlump faunules. Three are established to clarify the content of mudlump taxa. Close attention is paid to nomenclatorial matters.

A total of 186 molluscan species have been recognized in this and earlier studies of the mudlump fauna. Over 300 species of non-molluscan microfossils have previously been described from micromollusk-bearing clays. Ecologic data from all groups are integrated in an analysis of faunal homogeneity.

Though faunules differ in radiometric age and show heterogeneities in foraminiferal faunas, they are homogeneous with respect to mollusks. They represent a benthonic, 30- to 35-fathom, soft-bottom community. Fifty-four micromolluscan species are part of this community.

Categorical ratios within the micromolluscan community are compared with those of marine macroinvertebrate communities from limited geographic areas and restricted ecologic settings. Most of the fauna shows normal ratios, though a few familial-level taxa are divergent. Unusual territorial specializations and inadequacies in classification appear to explain anomalies.

INTRODUCTION

A few groups of mollusks consistently deviate from normal patterns of diversity and abundance in animals. Small forms are most divergent, and these can be placed in three mutually exclusive classes.

- Small species that are phyletically primitive
- Small species that are phyletically advanced and referable to superfamilies characterized by normal size
- Small species that are phyletically advanced and referable to superfamilies characterized by small size.

This classification is subjective but biologically valid. The last category groups Linnean taxa that have similar phyletic histories. They are here defined as micromollusks. A micromollusk is a member of a superfamily in which

- there is evidence that basic adaptations of the group reflect a phyletic trend toward smaller size
- representative species in major lineages are less than 6 mm in maximum diameter.

These characters distinguish micromollusks from other forms. Abnormal distributive patterns are common, though not universal, within the group.

The patterns of diversity and abundance from which many micromollusks deviate are conceptually simple. Faunal studies follow rather standard patterns, set by the hierarchical systems used. The categorical framework is uniform for studies of a particular sort,

and thus results are more or less comparable. Ratios between categories show the structure of the fauna and reflect factors which shape it. Ratios between ecologic categories, infauna and epifauna for example, show the influence of environmental parameters. Interpretation is largely a matter of common sense.

Within the Linnean hierarchy, certain ratios between categorical units can be more formally interpreted. Below the familial level, there is a basic regularity in faunas from small geographic areas and restricted ecologic settings. Study of 55 well-known faunas shows an average of 1.38 species per genus with 1.14 species per genus characteristic of marine communities (Figure 1). For micromolluscan communities, six is a more representative figure (Table 1). Normal faunas have 80 to 90% of the genera represented by a single species. In micromolluscan faunas, most genera are represented by two or more species and the incidence of new species is remarkably high.

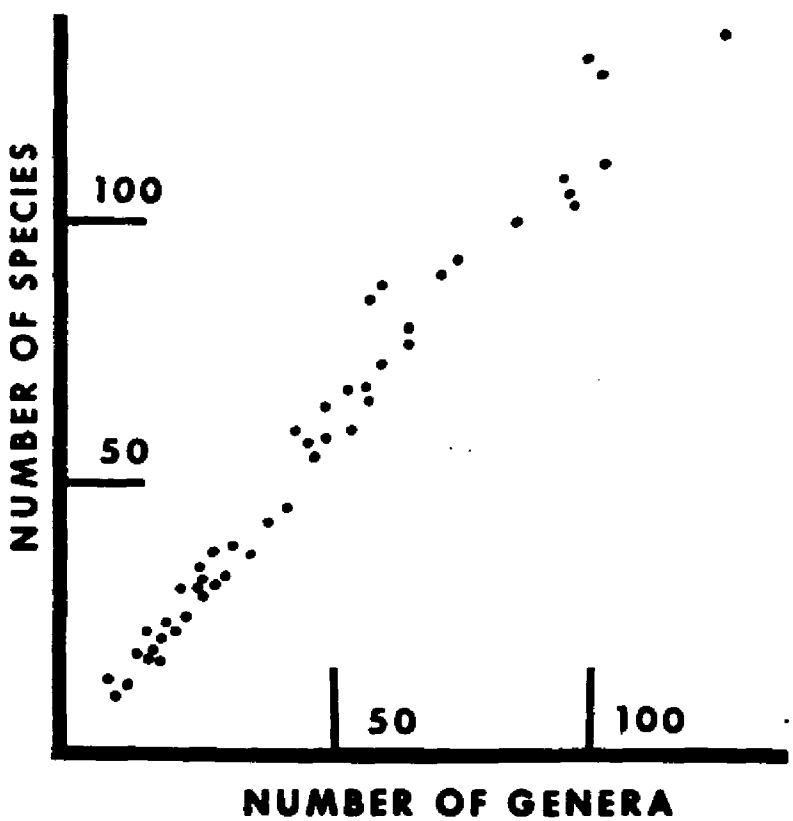
An evaluation of anomalies in categorical interrelationships within the Linnean hierarchy is essential to many phases of systematic research. In most studies of diversity and abundance, two or more classificatory systems are in concurrent use. The Linnean hierarchy supplies units which are then classified according to another system. Thus, in classifications based on ecologic, or ontogenetic, or phyletic characters, normalcy generally requires normal categorical interrelationships within the Linnean hierarchy.

Anomalies in categorical interrelationships within the Linnean hierarchy are primary anomalies and those derived from these are secondary.

Figure 1*

SPECIES/GENUS RATIOS

SMALL ECOLOGICAL COMMUNITIES



Average, animal 1.38

Maximum 1.63

Average, marine invert. 1.14

Maximum 1.31

Average, plant 1.22

Maximum 1.47

*After Elton (1946)

Table 1

NUMBER OF SPECIES AND NUMBER OF GENERA IN SOME MICROMOLLUSCAN FAUNAS

Area	Family	Total Species	Total Genera	Species Genus	% New Species	Authority
Florida Pliocene	Pyramidellidae	112	18	6.2	98	Bartsch (1955)
Florida Pliocene	Vitrinellidae	30	10	3.0	38	Pilsbry (1953)
Pho-Hai, Viet-Nam	Pyramidellidae	44	15	2.9	48	Saurin (1958)
St. Elena, Ecuador	Pyramidellidae	35	3	11.7	-	Bartsch (1924; 1926)
Atlantic, -1000 Fathoms	Siphonodentaliidae	28	3	9.3	-	Clarke (1962)
Pacific, -1000 Fathoms	Siphonodentaliidae	7	3	2.3	-	Clarke (1962)
Gulf of Thailand	Pyramidellidae	167	34	5.0	76	Saurin (1959)
Nhatrang, Viet-Nam	Pyramidellidae	210	43	4.9	28	Saurin (1961)
New Zealand	Pyramidellidae	204	37	5.5	68	Laws (1937a-1941)
West Panama	Vitrinellidae	155	17	9.1	45	Pilsbry and Olsson (1952)

Secondary anomalies must be evaluated in faunal comparisons. Interpretation of rates and patterns of evolution, description of community structure, and sound taxonomy require understanding of primary anomalies.

There are two apparent explanations for primary anomalies in micromollusks.

- Many micromolluscan elements in local faunas are not influenced by the same forces that shape the remainder of the fauna.
- Categorical units used in the classification of key micromolluscan groups are not comparable to those used in other groups.

Interpretation of anomalous categorical interrelationships in micromollusks appears to merit and require exhaustive systematic study. A logical beginning is the detailed description of individual faunas. A rich and well-preserved micromolluscan fauna occurs in Quaternary clays of the Mudlump Province of the Mississippi River Delta. Micromolluscan faunas of the northern Gulf of Mexico are almost totally unstudied.

MUDLUMP PROVINCE

The Mudlump Province is that portion of the Mississippi River Delta in which the Quaternary sedimentary sequence permits development of large clay diapirs. Mudlump is a sailor's term for the topographically evident diapir.

Present development of mudlumps is restricted to areas that are loci of current maximum sedimentation: the mouths of the major passes of the Mississippi River (Figure 2). Regional geological considerations strongly suggest that mudlumps formed at earlier stages in Mississippi River Delta development. Their distribution has yet to be delineated.

The geology of mudlumps and the Mudlump Province is quite well known (Morgan, 1961; Morgan, Coleman, and Gagliano, 1963; 1967; Coleman and Gagliano, 1964). Rapid deposition of relatively heavy modern sediments on lighter clays of the earlier Quaternary is the basic cause of diapiric intrusion.

The South Pass area (Figure 2) seems typical of the Mudlump Province and is known in greatest detail. An extensive boring program and detailed study of outcrops permit a reconstruction of the stratigraphic sequence (Figure 3).

Six sedimentary units are important in mudlump development. The oldest unit, termed the Strand Plain Sand, is deltaic and shallow marine in origin. It represents the maximum retreat of the sea during the last glacial interval.

A marine calcareous zone, above the Strand Plain Sand,

MISSISSIPPI RIVER DELTA

Figure 2

Figure 3*

STRATIGRAPHIC SEQUENCE

MUDLUMP PROVINCE

MODERN SEDIMENTS

CLAY UNIT I

CLAY UNIT II

CLAY UNIT III

CALCAREOUS ZONE

STRAND PLAIN SAND

--- SHELL HORIZON

*after Morgan et al. (1963)

1 inch =200 feet

yields radiocarbon dates of 26,500, ±1,450, and +37,000 years before present. It is succeeded by three clay units. The first and third of these are bluish-gray and montmorillonitic. They are interpreted as prodelta deposits formed during early stages of Recent delta development. Clay Unit II is reddish brown and its mineralogy suggests an Eastern source, unrelated to the Mississippi River (Gagliano, 1963).

The upper three to four feet of Clay Unit II is a shell hash. Radiocarbon dates average 15,375, ±537 years. Coleman and Gagliano (1964) recognize this unit in a well at Fort Jackson, Louisiana, some 30 miles north of the South Pass mudlumps (Figure 2). It may underlie all of the modern delta. Two similar shell horizons occur lower in Clay Unit II. Contrasts in radiocarbon age suggest the unit represents a duration of about 10,000 years.

The youngest sedimentary unit is the suite of sands and silts now accumulating. This unit is absent from most active mudlumps. Within mudlumps, sediments are highly deformed and estimation of stratigraphic thickness is difficult. Sediments above the calcareous horizon total about 575 feet.

Evolution of mudlumps involves the gradual transport to the surface of successively older sediments. In late phases of uplift, reverse faults expose shell hash horizons of Clay Unit II. Mudlumps at this point in development supplied all surface collections used in this dissertation. Collections are located in Figure 2. Names assigned mudlumps conform with all earlier paleontologic reports. Naming is discussed by Morgan (1961) and by Morgan, Coleman, and Gagliano (1963).

MATERIAL STUDIED

Collections differ greatly in size and were obtained by different means. Each is briefly described and Louisiana State University Department of Geology Museum Locality Collection numbers are assigned.

PAL 7

Collection.- Large, several pounds of washed aggregate.

Mollusks.- Eighty-three mollusks are listed in Appendix 1.

Collector.- Dr. Louis J. Wilbert.

Collection Number.- LSUDGMLC 2090.

Remarks.- Echinoderms dominate the fauna.

SP 1-B

Collection.- Faunules from this core hole represent three distinct horizons within Clay Unit II. Samples and sampling are discussed at length by Morgan, Coleman, and Gagliano (1963). Intervals studied are as follows:

Upper Horizon

-8.25 to 8.38'	-350.9 to 351.1'
-348.8 to 349.0	-351.8' to 352.0'
-349.6 to 349.8'	

Lower Horizons

-453.3'	-456.30 to 456.65'
-455.41 to 455.70'	-456.65 to 456.75'
-455.75 to 455.95'	-472.87 to 473.00'

Faunules from the upper horizon were used in a prior molluscan study (Barrelle, 1963). Only curated but unlabeled specimens were available. The -455.41 to 455.65' interval had also been curated. Mollusks from the lowest interval were listed by Barrelle but except for a few large shells, the faunule has been lost.

Mollusks.- Appendix 1 lists mollusks by interval. Seventy-four species are recorded from the upper horizon and 56 from the lower two. Records from Barrelle (1963) are not integrated with original listings of this report. Barrelle's lists seem to reflect study of the unprocessed core. He was thus able to identify large species.

Most species recorded by Barrelle and not reidentified are represented by available specimens. Unequivocal identification would require extended research. This is not germane to a study of micromollusks.

Collector.- Dr. James P. Morgan and the Coastal Studies staff.

Collection Number.- LSUDGMLC 2091.

SP 5

Collection.- One micropaleontological slide of univalve mollusks.

Mollusks.- Nineteen species are listed in Appendix 1.

Collector.- Dr. H. V. Andersen made the initial collection, and Dr. Alan H. Cheetham prepared the slide.

Collection Number.- LSUDGMLC 2092.

SP 6

Collection.- About one-half pound of washed aggregate.

Mollusks.- Only univalves were studied. Thirty-six species are listed in Table 1.

Collector.- Dr. H. V. Andersen.

Collection Number.- LSUDGMLC 2093.

SP 94

Collection.- About 30 pounds of material is available. Some 2.5 pounds of washed aggregate was examined in cursory fashion and half was examined in detail.

Mollusks.- Sixty-seven species are listed in Appendix 1.

Collector.- Prior to 1964, Dr. James P. Morgan and the Coastal Studies Institute staff had obtained collections from the island. Dr. Morgan, Dr. H. V. Andersen, Dr. Martin Mumma and the author collected during 1964.

Collection Number.- LSUDGMLC 2094.

MUDLUMP MICROMOLLUSKS

A micromollusk has anatomical, physiological, and ecological specializations that are size-dependent. These are integral parts of the structure of the animal. A small mollusk closely allied to normal-sized forms has the basic structure of a large animal. Primitive species are structurally primitive. A meaningful placement within the Linnean classification assures that this is true. Thus, phyletic size reduction is a more fundamental character of micromollusks than small size itself.

There are two basically different manifestations of a phyletic trend toward smaller size: present and historic. In the first, small size has, or appears to have, adaptive advantage for most members of a higher level taxon. Basic anatomy and, where known, the geologic record suggest a time-dependent sequence of morphologic changes that results in a smaller average size. The rissoid stock, discussed below, exemplifies this type of phyletic trend.

Historical trends are evidenced by the sudden appearance in the geologic record of a new and radically different group of small-sized organisms. In general, these appear late in the history of the Mollusca and invade habitats not densely colonized by mollusks. Within the new group, phyletic trends may or may not be size related, but establishment of the group apparently resulted from fundamental structural modifications only possible in small-sized organisms. The pulmonates are a fairly clear example of this. Molluscan groups in which phyletic trends toward small size are historic rather than

present are considered micromollusks only so long as they retain small size.

Evidence of phyletic size decrease, hence recognition of micromollusks, is generally somewhat nebulous. The limits of the group are approximate. Recognition requires evaluation of all data that bear on phylogeny and data are frequently inadequate. If a group of small mollusks is anatomically distinct from large forms and shows ecologic specializations only possible in small forms, it is considered a micromolluscan group. Selection pressure which tends to increase or maintain present adaptations fosters size decrease or maintenance of small size.

Molluscan classes differ so strongly in morphology and in the diversity of contained taxa that independent evaluation is called for. Three molluscan classes are represented in mudlump faunas: Pelecypoda, Scaphopoda, and Gastropoda.

Pelecypoda

Though pelecypods are the focus of much study, the class is not taxonomically diverse. Nicol (1958) estimates that there are 20,000 living species. This is roughly equaled by the gastropod order Pulmonata.

Newell (1949) has shown that phyletic trends toward large size are normal within the pelecypods. Yet it seems possible that reverse trends are also present. Small pelecypods that live commensally with worms reach adult sizes well under 3 mm and are smaller

than any apparent ancestor. Hampson (1964) provides observations on ecology but the phylogeny of these small forms seems to be little known. They are generally placed in a separate superfamily, the Leptonacea, and appear to represent a strongly divergent marine pelecypod lineage.

These very small forms are not represented in the mudlump fauna and none of the mudlump pelecypods (Appendix 1) appears to be a micromollusk.

Scaphopoda

Knowledge of scaphopod phylogeny has been summarized by Emerson (1962). The first definite scaphopods are Devonian and are referred to the extant family Dentaliidae. Few geologically younger scaphopods approach the size of these earliest forms.

During the Mesozoic, eight new generic level taxa developed. All are characteristically smaller than Late Paleozoic forms. In the Upper Cretaceous, a second family of Scaphopoda, the Siphonodentaliidae, appeared. This group is characteristically far smaller than the Dentaliidae.

The earliest siphonodentaliids are referred to Cadulus (Gadila) and are succeeded in time by taxa both larger and smaller. Species referred to Cadulus (Cadulus) are the smallest siphonodentaliids. This group appeared shortly after Cadulus (Gadila) and reached an apparent minimum size in Eocene forms like Cadulus (Cadulus) mcfarlanae which is adult at 1.1 to 1.3 mm (Emerson, 1957). Modern faunas (e.g. Henderson, 1920) contain the greatest diversity of small

forms. Thus, it seems that the entire class Scaphopoda shows evidence of phyletic size decrease.

Only the Siphonodentaliidae are normally under 6 mm in adult size. Dentaliid scaphopods are excluded from study. Siphonodentaliids are treated at length in Section A of the Systematic Descriptions. All are species of Cadulus and distribution is shown in Appendix 1.

Gastropoda

In a survey oriented toward understanding micromolluscan categorical ratios, extended systematic description of well-known forms is not called for. They are briefly discussed below and more troublesome groups are treated in greater detail.

Bubbles.- A number of opisthobranch families are popularly called "bubble shells." These are represented by one or more species in the Ringiculidae, Bullidae, Atyidae, and Retusidae.

Except for the Ringiculidae, these families are beyond the province of a study based on shells. The adult animal in the Bullidae, Atyidae, and Retusidae is never completely enclosed by its shell. Thus, shell dimensions are not a guide to the size of the animal.

In the Ringiculidae, complete withdrawal is possible. All species are small and, on anatomical characters, the animals are considered the most primitive opisthobranchs (Fretter and Graham, 1962).

Ringicula first occurs in the Cretaceous. Two of the earliest species average about 5.35 mm in length (Kauffman and Pope, 1961). This is considerably larger than Neogene species (Weisbord,

1962; Gardner, 1937) and Paleogene forms seem to be of intermediate size (Aldrich, 1897). This suggests that Ringicula and the Ringiculidae are micromollusks; however, the group is phyletically primitive, living forms are epibiotic, and the Cretaceous ringiculid Biplica shows a trend toward size increase (Popenoe, 1957).

Status of the Ringiculidae is, at present, indeterminate. Distribution of ringiculids in mudlump faunules is shown under Ringicula in Appendix 1.

Eulimids.- A series of anatomically oriented papers (Fretter, 1955; Fretter and Graham, 1962) shows that the Eulimacea are obligate parasites. Phylogeny is not clear but their basic anatomical and dietary adaptations are only possible in a small animal.

Eulimids are quite varied. The group includes both ectoparasites and endoparasites. Typical forms prey on vagrant hosts and appear to spend most of their life cycle resident on or in an individual host animal.

The mudlump eulimid fauna, and the eulimid fauna of the Western Atlantic, is nomenclatorially simple and includes few species. The three mudlump eulimids are Niso interrupta, Balcis intermedia, and Eulima bifasciata. Distribution is given in Appendix 1.

Pelagics.- There is a lure to pelagic mollusks that reflects itself in an abundance of studies of fossil and modern forms. These result in a complex nomenclatorial history and a confusing geological record. Three groups of pelagic gastropods occur in the mudlump fauna.

Litiopa melanostoma, the Sargassum snail, is a small cerith,

a specialized member of a superfamily in which all typical forms are moderately large. Palmer (1942; 1944) discusses the nomenclatorial history of this species and traces its geographic distribution. It is well known and not a micromollusk.

The heteropod genus, Atlanta, is represented in mudlump collections by its type species, Atlanta peroni. Coen (1965) reviews generic nomenclature. Characters and distribution of the species are well known from hundreds of dredging reports. Remarks on pteropods, below, are equally applicable to the heteropods.

Pteropods are the principal group of pelagic mollusks in mudlump faunules. They were long believed to have originated in the Upper Cretaceous (Shimer and Shrock, 1945) but pre-Tertiary records are now open to serious doubt. Records of Mesozoic Pteropoda from the Middle East are spurious (Avnimelech, 1945). This had been the area in which Mesozoic forms were believed to be most abundant.

Clear records of the pteropods begin in the Early Tertiary. Within the Western Atlantic faunal realm, Collins (1934) shows there has been no significant size decrease.

A pelagic way of life is open to animals of virtually any size and it would seem that selection pressures within the pelagic realm do not necessarily foster development of smaller forms.

In the pteropods, heteropods, and other pelagic mollusks, a phyletic trend toward small size appears to be historic, a character of ancestral populations and not of modern taxa.

Fager and McGowan (1963) show that categorical interrelationships within the pelagic molluscan community are more or

less normal and McGowan (1960) has done much to rectify the nomenclature.

Distribution of mudlump pelagic species is given in Appendix 1 under Atlanta, Cavolina, Clio, Creseis, Litiopa, and Spiratella.

Rissoids.- Figure 2 in the Systematic Descriptions shows that in one Miocene to Recent genus of the rissoid stock, eleven species display an overall reduction in size that correlates with stratigraphic appearance and sculptural changes. This strongly suggests phyletic size decrease in the genus. Most interpretation of size decrease rests on less direct evidence: anatomically based inference of long-continued selection pressure favoring smaller size.

Fretter (1948) and Fretter and Graham (1962) describe the anatomy of a host of small species referred to the Rissoacea or placed in an Incertae Sedis group allied to the Rissoacea. Most of these small forms do not have an informative fossil record. Descriptions are generally poor. Most generic level taxa have complex nomenclatorial histories and interpretation of any one species is a major undertaking that generally leads to equivocal results.

The Rissoacea s.l. are characterized by loss of, or reduction in, organ systems that are generally necessary to sustain life in animals of larger size. An adult discoidal gastropod 1 mm in maximum dimension has respiratory and excretory needs different from those of a large animal. The dermal surface is disproportionately great and

more nearly adequate for exchange with the aqueous environment. Reduction in respiratory and excretory systems is common in the rissoids.

Small species with reduced lungs or without lungs are clearly descended from species in which life was dependent upon functional lungs. Lunglessness is size-correlated and appears to result from long-continued selection pressure favoring small size.

Other examples of loss and reduction in organ systems might be given, but one serves to indicate a general relationship between simplification and smallness.

Small gastropods have also developed a number of anatomical specializations that do not occur in large forms, other than possible descendants. Some of the most interesting relate to water walking.

Very small gastropods walk on the surface of the sea, generally on the underside of the surface film. This is clearly documented in habitat studies by Fretter (1948). She observed grazing at the sea surface in three species of the rissoid stock referred to the families Omalogyridae, Skeneopsidae, and Rissoidae. Two of her species produce a large volume of pedal mucous, increasing the surface area of the foot and reducing the weight per unit area of water-mollusk contact.

One species, Skeneopsis planorbis, is capable of constructing a mucous float which is separate from the animal. In very shallow water, it can descend from the float to the bottom by secreting a mucous thread. If the animal runs out of secretion before reaching the bottom, it climbs back up its thread. Neither the thread nor

the float is necessary to sustain Skeneopsis at the surface. Like the other small species, it can walk on water.

Water-walking snails are morphologically diverse: high and low spired, smooth and rough gaited, lung-bearing and lungless, etc. All of Fretter's specimens lived in rock pools and they may not be able to walk on water in the normal marine environment.

Fretter is the best qualified to generalize on her own observations. This has, in general, not been done. The following points seem significant.

Three families of marine gastropods have, apparently independently, evolved a potential for pelagic life. They differ in the most fundamental anatomical characters (e.g. the nature of the respiratory system).

Water walking is size-dependent for it requires that weight per unit area of foot surface and foot margin-water surface relationships permit movement without breaking a surface film.

Known water walkers are herbivorous and primarily adapted to a benthonic life. Water walking greatly increases grazing area by adding new territory. By altering territorial limits, water walking also removes the need for competition with other taxa for the available supply of bottom food.

Lunglessness and water-walking are but two of the myriad specializations of the rissoid stock. Other rissoids are involved in cleaning consortia with larger mollusks. A few live in the gills of worms. Some may be parasitic. In a few, the digestive system is

very specialized, with associated restrictions in the possible range of foods. Most show anatomical specializations that better equip them to fill ecologic niches only open to very small animals. This and size itself suggest rissoids are micromollusks.

The mudlump rissoid fauna is diverse and difficult to deal with. It is described in Section B of the Systematic Descriptions. Distribution is shown in Appendix 1 under Alvinia, Aorotrema, Cerapons, Circulus, Elephantanellum, Episcynia, Micranellum, Parviturboides, Phosinella, Vitrinella, Zebina, and Zebinella.

Liotiids.- Reviews of the Liotiidae and related families (Pilsbry, 1934; Laseron, 1954; 1958; Abbott, 1950) suggest they are an archaeogastropod analogue of the rissoid complex in the Mesogastropoda: a very varied stock of herbivorous microgastropods.

In the world fauna, liotiids and rissoids are frequently confused. One liotiid, Arene lis Corgan, new species, occurs in mudlump faunules and is part of a species complex that has, historically, been referred to the rissoid family Vitrinellidae. Arene lis is treated at length in Section B of the Systematic Descriptions. Distribution is shown in Appendix 1.

Pyramidellids.- Pyramidellids are obligate ectoparasites. Typical forms spend most of their time on the substrate and come in contact with prey only in the act of feeding. Some parasitologists (e.g. Baer, 1951) regard them as non-lethal predators, but malacological conventions are here followed and pyramidellids are considered parasites.

The geologic record of the Pyramidellacea is very confused. Few groups are as nomenclatorially complex. Anatomy is the best source of phyletic data.

Pyramidellid anatomy shows extreme specialization in the ingestive and digestive systems which correlates with major changes in reproduction, foot morphology, and glandular tissues. The overriding specialization is dietary. All organ systems are modified to facilitate sucking. In this they differ radically from presumed ancestral forms.

Most pyramidellids fall within the size range of micromollusks and their basic adaptation appears to require small size. Pending increased knowledge of phylogeny, pyramidellids are considered micromollusks.

Most mudlump pyramidellids cannot be referred to established species and the fauna is extremely varied. It is described in Section C of the Systematic Descriptions. Distribution is shown in Appendix 1 under Besla, Chrysallida, Eulimastoma, Kilatus, Longchaeus, Syrnola, and Turbonilla.

FAUNAL HOMOGENEITY

Understanding categorical relationships of mudlump micromollusks requires evaluation of the nature and number of faunal assemblages represented by available samples. Differences in age and environment are the primary potential sources of diversity within the fauna. Faunules are compared below. Environment, age and taxonomic diversity of mollusks are separately discussed. A faunal comparison and bathymetric data are given in Appendix 1.

Ecological Homogeneity

PAL 7.- Eighty-two molluscan species are known from PAL 7. They seem quite comparable to other mudlump faunules (Appendix 1). Few species range into the intertidal zone and few range to depths greater than 150 fathoms.

Abundant scaphopods and burrowing clams imply a fairly soft bottom. A clay matrix also suggests this. Many molluscan shells are overgrown by Bryozoa or worm tubules. Others are heavily bored. Some shells have color preserved and may represent undisturbed infauna. All biologic parameters suggest slow sedimentation.

The planktonic element in the PAL 7 molluscan fauna (Table 2) indicates clear surface water, open marine conditions, and great distance from a significant source of suspended sediment. Over a three-year period, Burkenroad (1933) dredged pelagic mollusks off the Louisiana Coast. He did not note a multispecific assemblage even

Table 2

BATHYMETRIC RANGE OF KEY MOLLUSKS FROM PAL 7

(Depth in Fathoms)

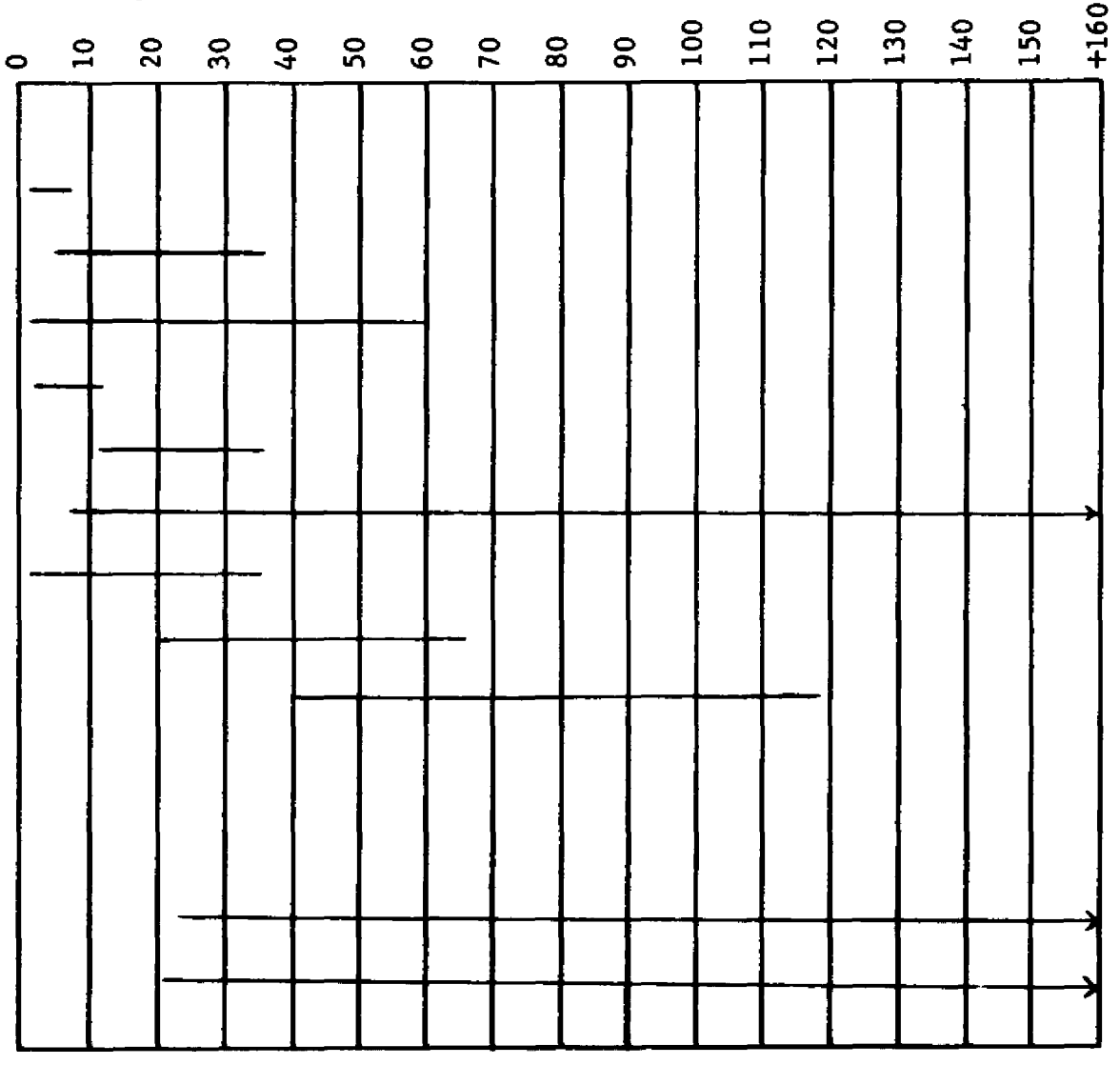


Table 2 (Continued)

Atlanta peroni	pelagic
Aurinia schmitti	
Cavolina inflexa	pelagic
Cavolina longirostris	pelagic
Cavolina quadridentata	pelagic
Cavolina trispinosa	pelagic
Circulus pentagonus	
Clio polita	pelagic
Clio pyramidata	pelagic
Fasciolaria lilium	
Fusinus eucosmius	
Litiopa melanostoma	pelagic
Longchaeus candidus	
Niso interrupta	
Pleuroliria tellea	

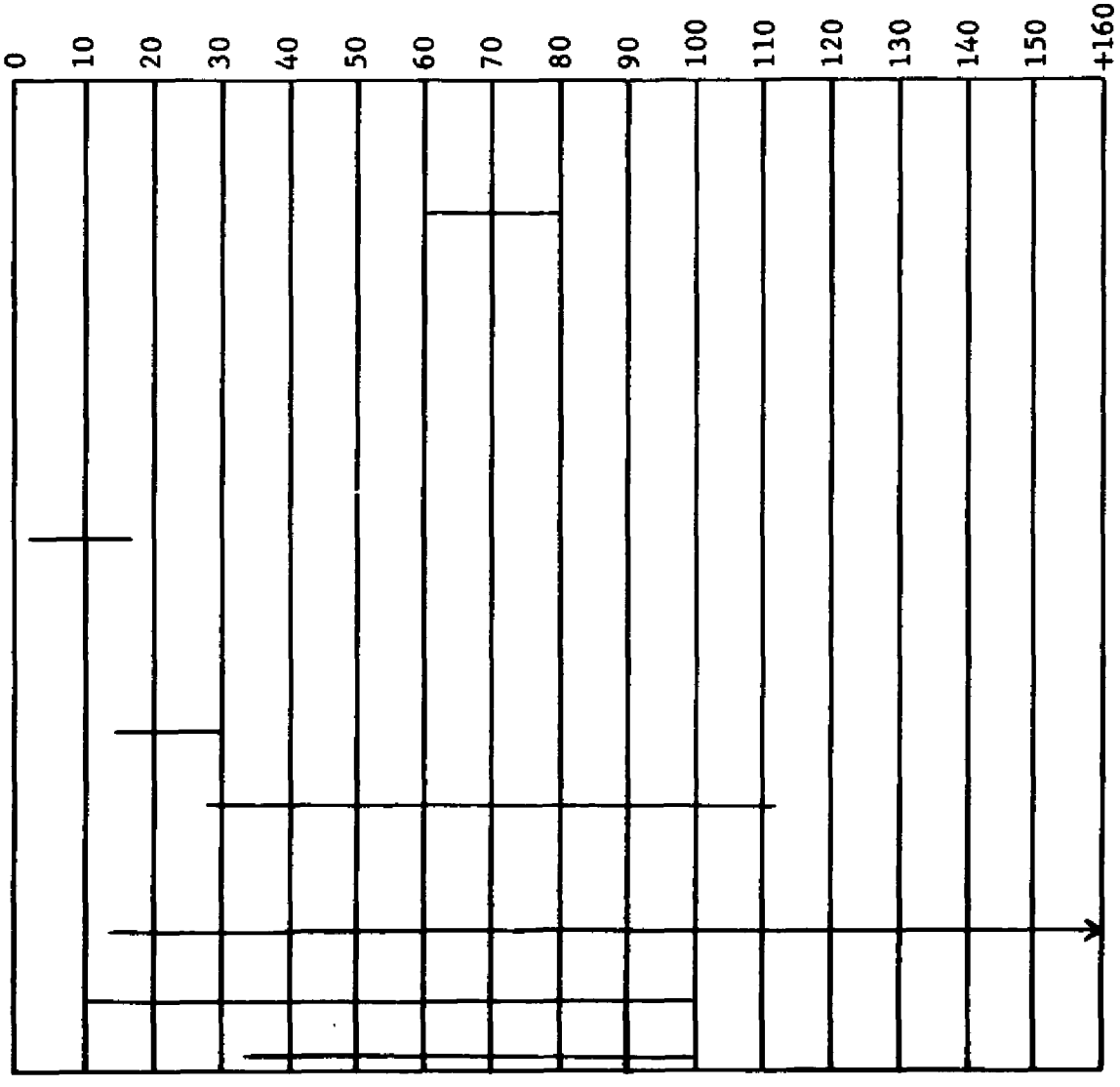
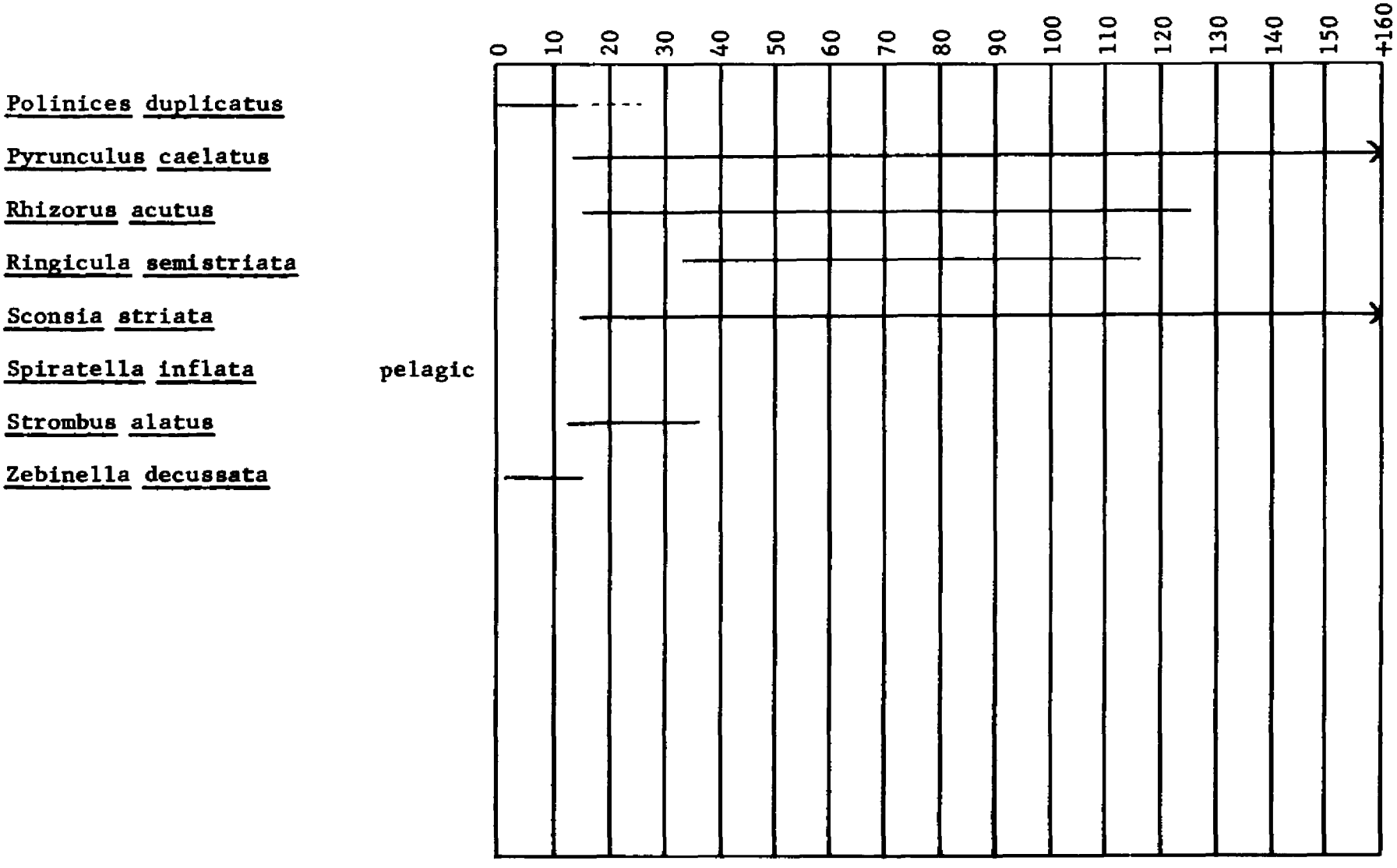


Table 2 (Continued)



grossly similar to the PAL 7 fauna until he reached distances of 30 to 40 miles from shore.

Kornicker (1959) and many others record rare monospecific pteropod blooms in very shallow water but pelagic mollusks normally occur in multispecific associations. PAL 7 species represent parts of normal associations.

Pelagic molluscan associations follow a cycle of vertical migration through the water mass that correlates with the diurnal cycle and is necessary to sustain life. Minimum bathymetric requirements of most species are roughly known and associations of species have been described (Wormelle, 1962; Chen and Be, 1964). Since the PAL 7 fauna is not a life association, precise application of data from life occurrences is meaningless. Still, PAL 7 must have been near a region where varied associations of pelagic mollusks could live. This is not generally possible in waters less than 30 fathoms deep.

A few benthonic species have maximum published ranges near ten fathoms. Two of these, Caryocorbula cubaniana and Polinices duplicatus, actually range down to 25 fathoms or more. They are common in the bottom sediments collected during seismic surveys in the Gulf. Other shoal water species are not sufficiently well known to permit reliance on their published maximum depths.

In Table 2 there is a significant break at 30 to 40 fathoms. Chione clenchi, Nuculana proxima, Nuculana concentrica, Fasciolaria lilium, and Strombus alatus range down to about 35 fathoms. Ringicula

semistriata, Yoldia solenoides, and Pleuroliria tellea do not occur in waters shallower than about 35 fathoms. Quite an array of deeper water species range into waters slightly shallower than 35 fathoms but deeper than 20 fathoms. These include Pitar cordata, Ancistrosyrinx radiata, Antillophos candei, and Fusinus eucosmius.

From the known bathymetric ranges of Mollusca, it appears that fossiliferous sediments of PAL 7 were deposited in about 35 fathoms of water. This is compatible with the occurrence of a varied fauna of pelagic mollusks that are dependent upon diurnal migration.

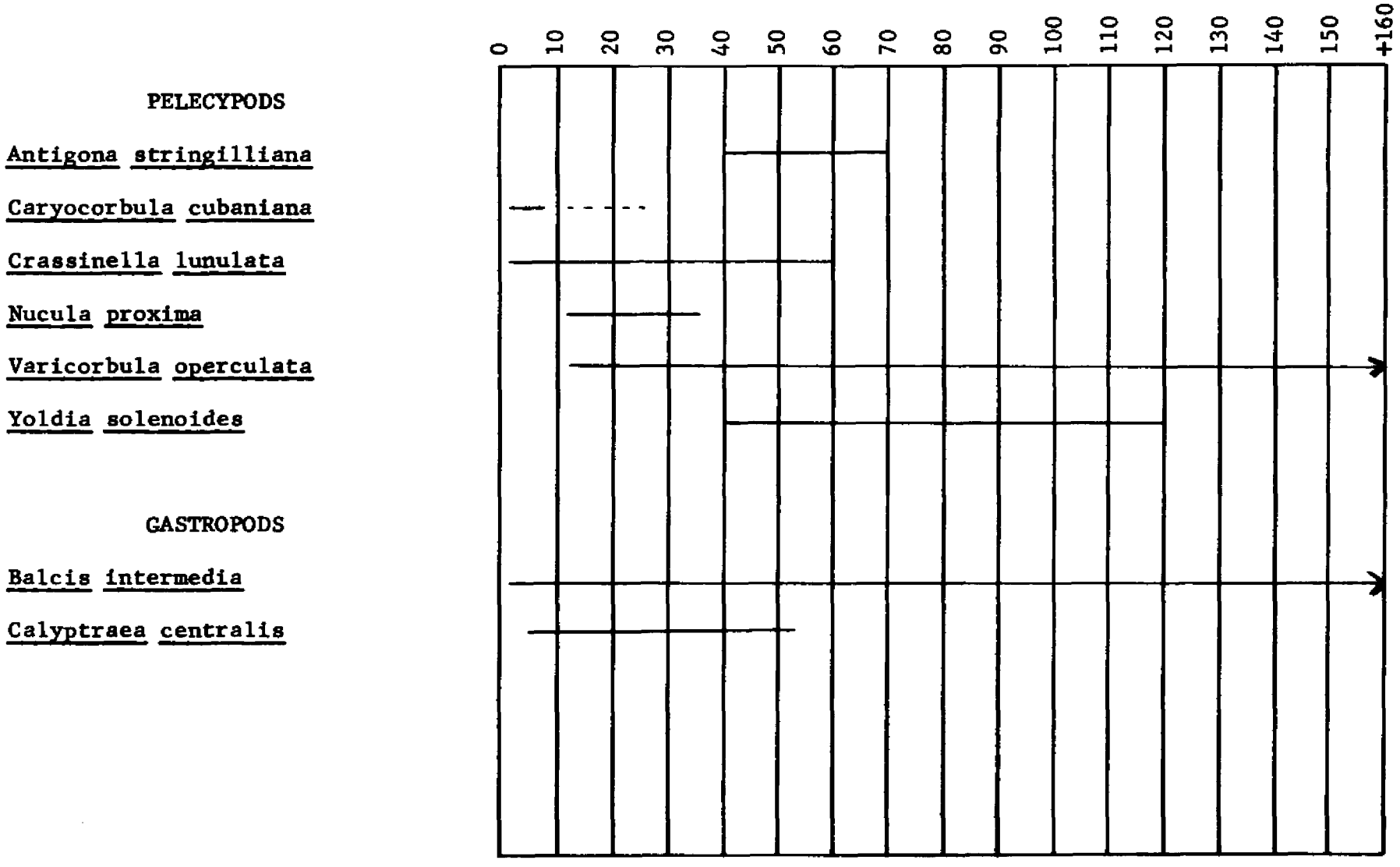
In summary, mollusks from PAL 7 represent a soft-bottom community that lived in the open sea, far from shore, in about 35 fathoms of water.

SP 1-B, -8.25 to 8.38'.- Andersen (1963), Barrelle (1963), and Corgan (1965) are sources of paleontologic information on this interval. Morgan, Coleman, and Gagliano (1963) is a source for sedimentological and structural information.

Mollusks from the -8.25 to 8.38' interval are listed in Appendix 1, and depth ranges of key species are shown graphically in Table 3. The faunule is small and not diverse. A gross comparability with PAL 7 is evident but some groups--notably pelagic and parasitic forms--are absent. A discordance between 25 and 40 fathoms suggests deposition within this range (Table 3).

From foraminiferal faunas, Andersen (In Morgan, Coleman, and Gagliano, 1963) interprets the -8.25 to 8.38' interval as a structural repetition of the -348.8 to 352.0' horizon in SP 1-B. Mollusks

Table 3
BATHYMETRIC RANGE OF KEY MOLLUSKS FROM SP 1-B, -8.25 to 8.38'
(Depth in Fathoms)



support this hypothesis. The higher interval is thus equated with the lower.

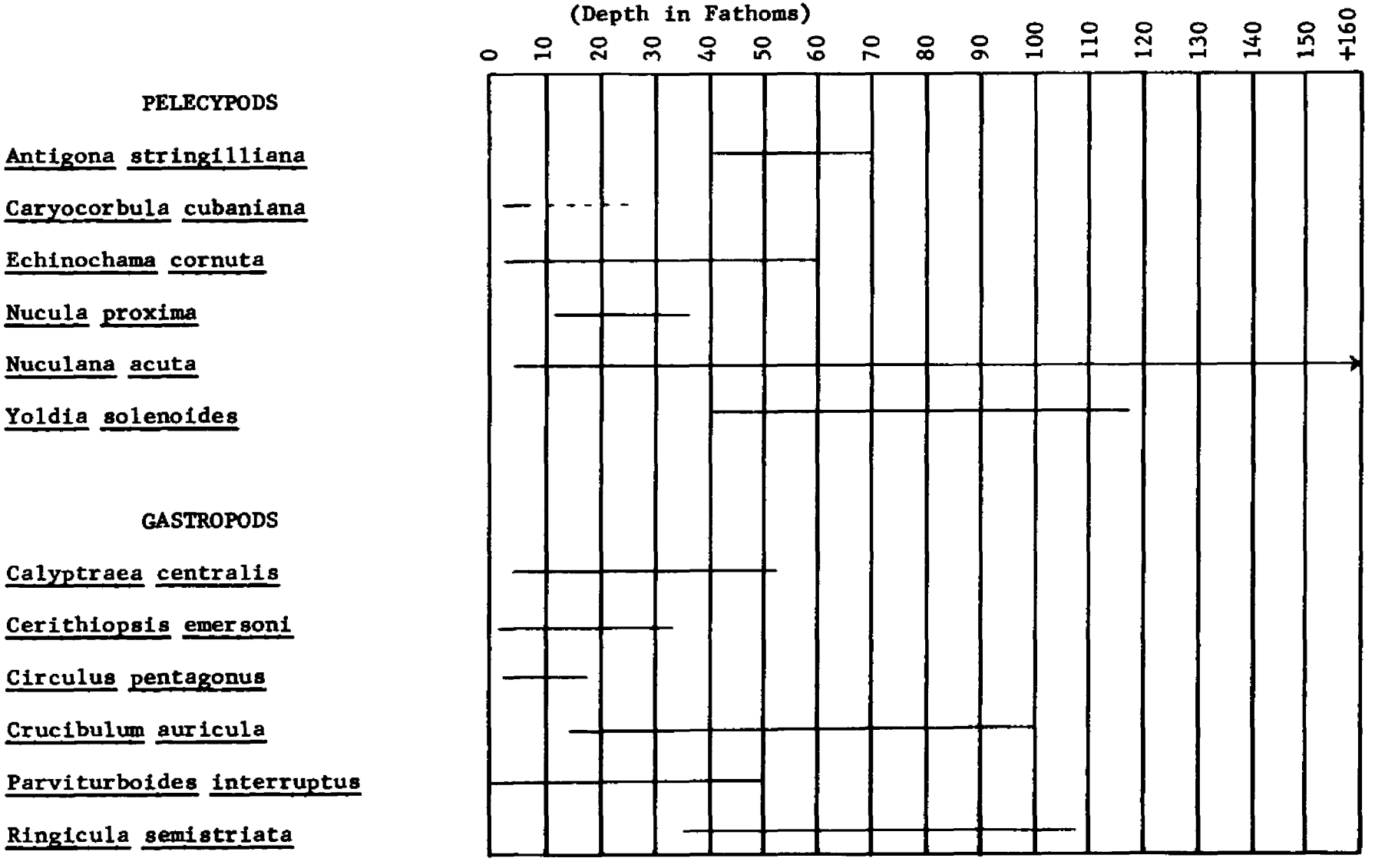
SP 1-B, -348.8 to 352.0'.- Sources of data are the same as for the unit above. Bathymetric ranges of key species are shown in Table 4. Antigona stringilliana, Yoldia solenoides, and Ringicula semistriata live at depths below 35 to 40 fathoms, while Caryocorbula cubaniana, Nucula proxima, Cerithiopsis emersoni, and Circulus pentagonus occur above 30 or 35 fathoms. This suggests a paleobathymetry comparable to PAL 7, about 35 fathoms. Most bathymetrically significant species are the same. Yet interpretation of the PAL 7 faunule stressed the importance of pelagic mollusks. They are poorly represented in the -348.8 to 352.0' interval. The -350.9 to 351.1' subsample yields the only pelagic form, a single Cavolina trispinosa.

Abundant gastropods comparable in size to pelagic forms suggest these were not removed by depositional sorting. There are at least three plausible explanations for differences between the pelagic faunas of this locality and PAL 7. Random fluctuations in abundance on a uniform bottom is the most probable explanation. Differences might also reflect the differing proximities to even deeper water of two sites that were, themselves, equally deep. Finally, the South Pass area might have been slightly shallower, on the order of 30 fathoms.

Overgrown and bored shells, incidence of burrowing mollusks, sedimentary characters, and gross faunal association suggest that other aspects of the depositional environment were comparable to PAL 7.

Table 4

BATHYMETRIC RANGE OF KEY MOLLUSKS FROM SP 1-B, -348.8 to 352.0'



Foraminifera provide an alternate basis for paleobathymetric interpretation of all SP 1-B horizons. Andersen (In Morgan, Coleman, and Gagliano, 1963) suggests deposition in about 25 fathoms. Molluscan and foraminiferal interpretations are thus in close accord.

SP 1-B, -453.3 to 456.8'.- Sources of information on this interval are the same as for other horizons in the SP 1-B boring. Parasitic and pelagic species are absent (Appendix 1). Bathymetric ranges of key forms are summarized in Table 5.

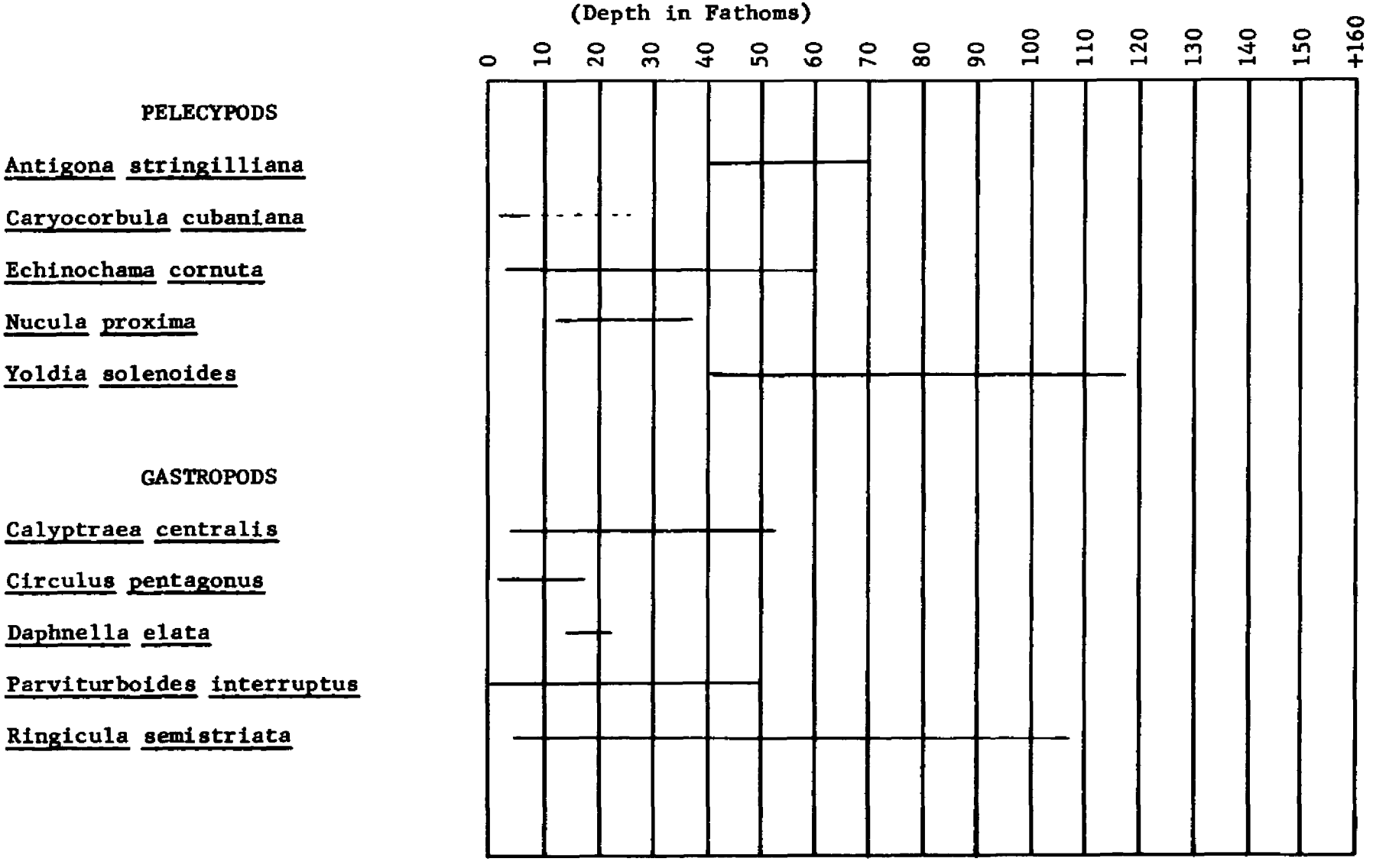
Virtually every bathymetrically significant species from this interval occurs in faunules discussed above. The interpretation is, thus, the same: 30 to 35 fathoms. Absence of pelagic species makes the shallower figure more probable.

Foraminiferal data suggest deposition in about 50 feet, or 8.3 fathoms (Andersen, In Morgan, Coleman, and Gagliano, 1963). Andersen's interpretation is broadly based. Over 5,000 specimens were evaluated and great significance was attached to relative abundance. In paleoecologic reconstruction, Andersen's interpretation merits greater credence than an interpretation based solely on mollusks. In an evaluation of the homogeneity of molluscan faunules, this is not true. An environmental difference that does not result in a change within the molluscan fauna is not a significant environmental change within the limited context of a study of mollusks.

Intertidal mollusks do not make a significant contribution to the fauna of the -453.3 to 456.8' interval. These sediments would appear to reflect deposition below the common range of intertidal

Table 5

BATHYMETRIC RANGE OF KEY MOLLUSKS FROM SP 1-B, -453.3 to 456.75'



species, about 12 fathoms. Thirty fathoms seems most probable.

This interpretation is not necessarily correct, but it is the only interpretation that can be based upon, or substantiated by, or used in a study of mollusks.

SP 1-B, -472.9 to 473.0'.- Except for a few large specimens, mollusks from this interval were lost prior to inception of this study. Knowledge of the molluscan fauna comes from Barrelle (1963), with the addition of Caryocorbula cubaniana and the pteropod Cavolina longirostris (Appendix 1). Gross faunal composition is quite comparable to other intervals in SP 1-B. Barrelle (1963) suggests 12 to 40 fathoms as the probable depth of deposition. He also interprets the fauna as indicative of somewhat shallower depths than other intervals in SP 1-B.

Andersen (1963; In Morgan, Coleman, and Gagliano, 1963, fig. 8, p. 29) considers this interval comparable to -453.3 to 456.8'. He suggests a depth of about eight fathoms. No new data are available which bear on the interpretation of this faunule.

SP 5.- Few faunas have been as exhaustively studied as the fauna of SP 5. Andersen (1961) described about 210 species of Foraminiferida. Cheetham and Sandberg (1964) described 43 species of Bryozoa and Joerger (1959) discussed 15 species of Ostracoda.

Few mollusks were available for study, and these are prime specimens. The fauna is thus not comparable to those of other mudlump samples. SP 5 and SP 6 are geographically proximate and appear to be at the same stage in mudlump evolution (Morgan, 1961). Their molluscan

faunas are therefore evaluated together. The paleoecologic implications of other elements in the SP 5 fauna are here summarized.

The bryozoan fauna contains four species of cyclostomes and 39 species of cheilostomes; two of these are described as new (Cheetham and Sandberg, 1964). About 134 species of cheilostomes had previously been recorded from the Gulf of Mexico. Thus, SP 5 yielded a fauna about 30% as diverse as that previously known from the entire Gulf of Mexico. Cheetham and Sandberg (1964) assembled bathymetric data for the 37 previously described species of Cheilostomata and concluded that a depth of 20 to 50 fathoms was indicated.

Andersen's work with Foraminiferida (Andersen, 1961) was a pioneer treatment of Quaternary Foraminiferida of the Gulf of Mexico region. About one-third of the species are either new or reported as nomina aperta: identified with question, compared with described species, identified by affinity, or labeled undetermined.

Andersen's 1961 report grew out of an unpublished manuscript (Andersen, 1950) written when there were only two publications on Recent Foraminiferida of the Lower Mississippi Delta. Long-delayed publication permitted updating through 1959.

Lack of a frame of reference prevented a broadly based bathymetric interpretation. Shoal water faunas had been described and deep water faunas were fairly well known but little had been done with faunas from intermediate depths (Andersen, personal communication). Initial interpretation reflected available control and suggested deposition at about 65 fathoms (Andersen, 1961, p. 20).

Andersen later interpreted the higher Clay Unit II fauna

in SP 1-B as a 25-fathom assemblage (Andersen In Morgan, Coleman, and Gagliano, 1963). Faunas are very similar. In large part, this change reflects broadening the basis for paleoecologic interpretation (Andersen, personal communication).

Bathymetric data from Bryozoa and Foraminifera are thus in accord. A study of ostracods from SP 5 (Joerger, 1959) does not contribute materially to paleoecologic reconstruction.

SP 6.- For both SP 5 and SP 6, only very small mollusks have been curated. This severely restricts an assessment of ecologic characters. Bathymetric ranges of key species are shown in Table 6 and further data are given in Appendix 1.

Pelagic mollusks are notably abundant. Diagnostic benthonic forms also occur in PAL 7. A depth of 35 fathoms or more is suggested.

SP 94.- Bathymetric ranges of key forms from SP 94 are shown graphically in Table 7. One species is anomalous: Pinctada radiata, a shallow water tree oyster, is represented by one specimen. Rafting explains its occurrence.

The SP 94 fauna is fairly rich in bathymetrically significant species. Conus clarki, Distorsio mcgintyi, and Sconsia striata are all well-known, deep-water forms. Added to the usual mudlump indicators of deep water, they suggest a minimum depth of 25 fathoms. The abundance of forms which share essentially the same up-shelf maximum suggests the true depth is probably below this maxima.

Pelagic mollusks are common in SP 94 but not as varied as in SP 6. Still, the pelagic fauna is well balanced and suggests fairly deep water, below 30 fathoms.

Table 6

BATHYMETRIC RANGE OF KEY MOLLUSKS FROM SP 5 AND SP 6

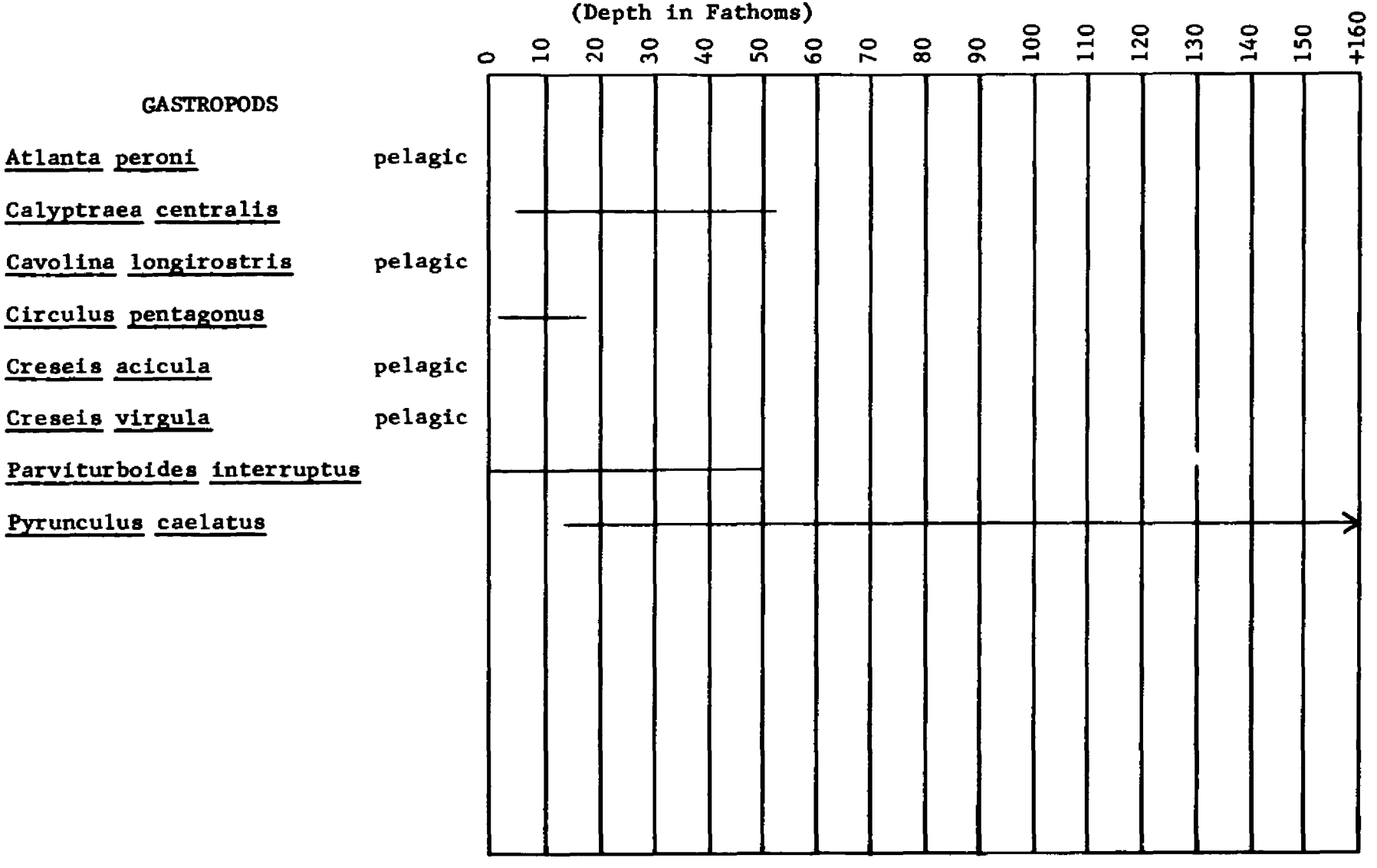


Table 7
BATHYMETRIC RANGE OF KEY MOLLUSKS FROM SP 94

(Depth in Fathoms)

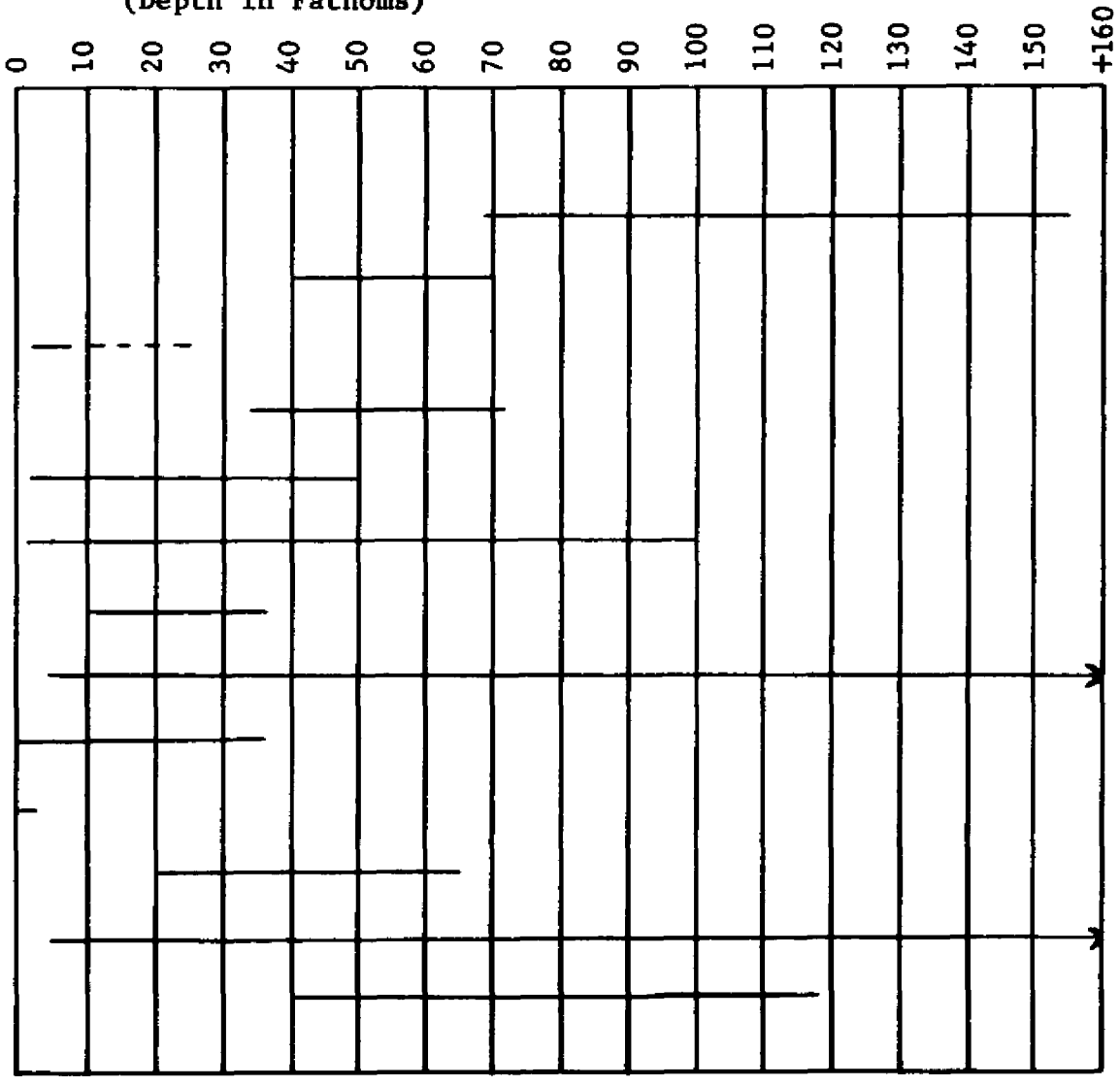


Table 7 (Continued)

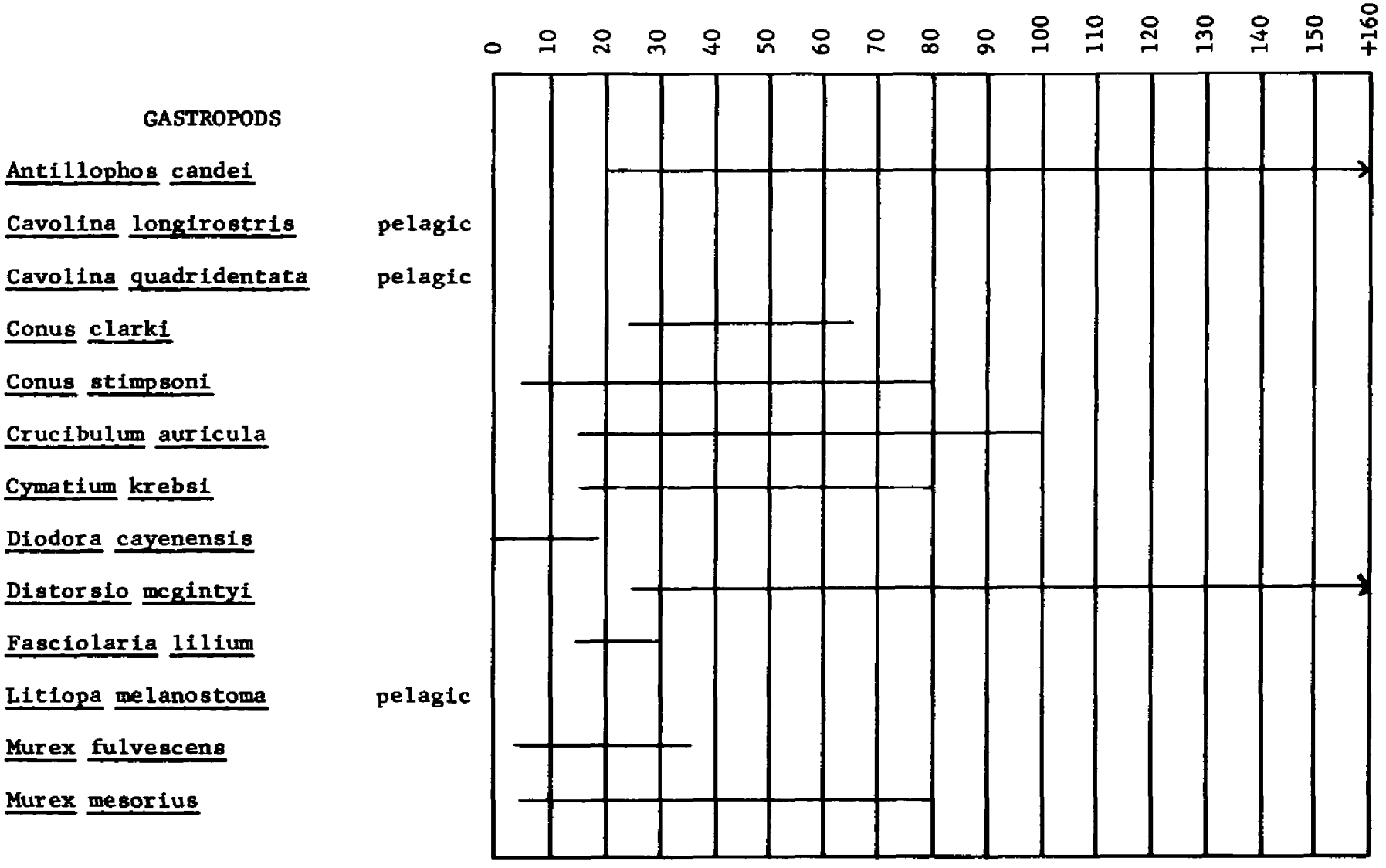
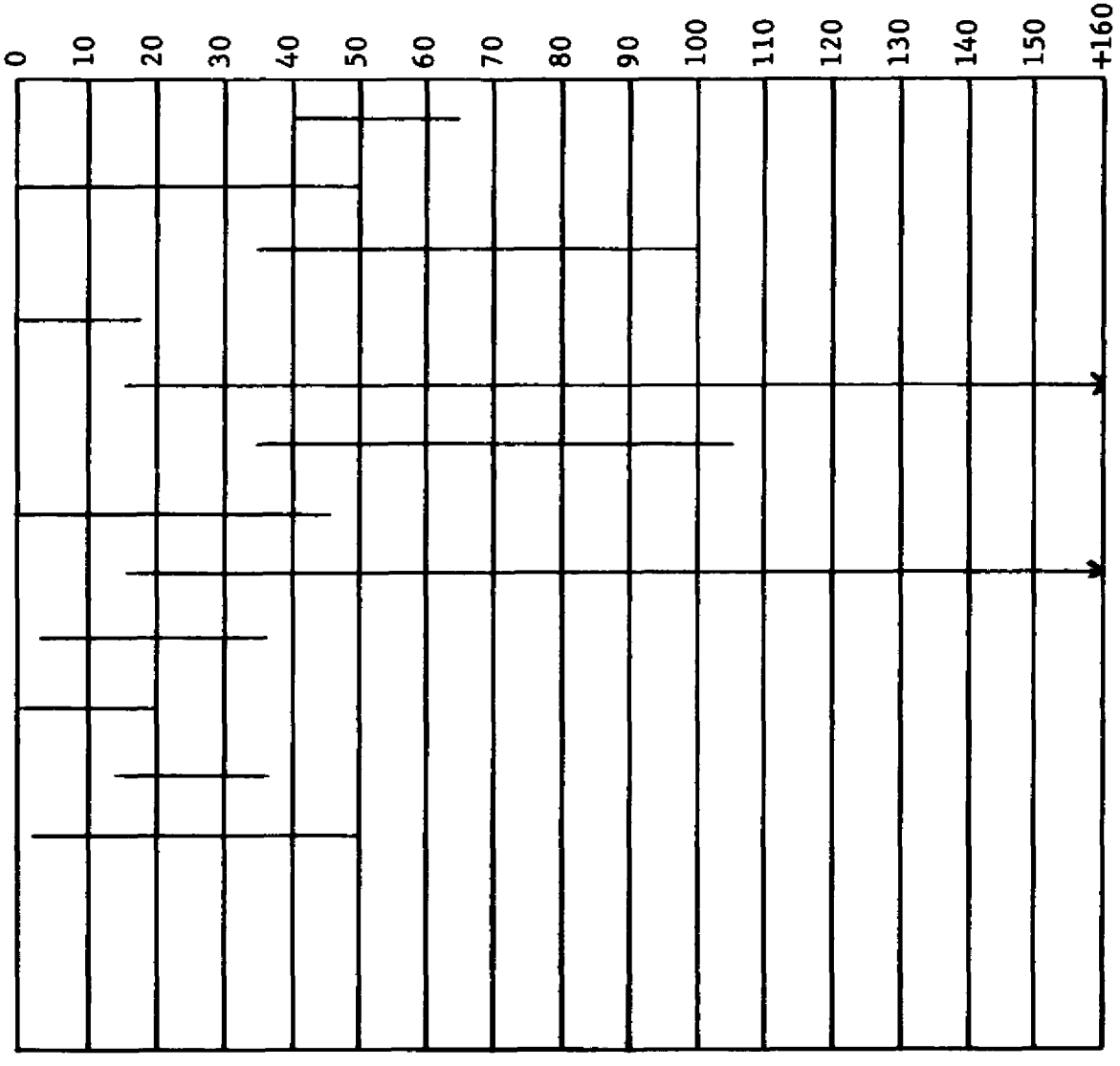


Table 7 (Continued)



A few species from SP 94 indicate rather shallow waters. Diodora cayensis is particularly well known. Its deepest authenticated occurrence is 19 fathoms (Farfante, 1943). Murex fulvescens, another well-known and common shallow water species, has never been recorded below 25 fathoms (Clench and Farfante, 1945).

Thirty fathoms appears to be the most probable depth of deposition.

General condition of the fauna from SP 94 suggests that the sea floor in this area was the focus of more energy than it was in areas represented by other mudlump faunules. More shells are worn and there appears to be a higher incidence of broken shell, though this is not certain without quantitative study. In SP 94, there appear to be more specimens overgrown by worm tubules or other fouling organisms. More shells are burrowed, bored, or otherwise modified after death.

The fauna of SP 94 is also taxonomically distinctive (Appendix 1). A firmer bottom appears to be the principal cause of distinctiveness. On the outcrop, there are occasional large plate-like slabs of carbonate. These are an intergrowth of Echinochama with a calcareous worm. Thickness is generally about four inches with an irregular bottom and a more or less regular top.

Oysters occur in SP 94 and are absent from other faunules. Large scallops are very abundant and there are a number of ark shells. All these filter-feeders are distinctive of SP 94.

Large, sessil species apparently attracted large, vagrant carnivours. Natica, Murex, Conus, and Terebra are known only from

this location.

A slightly firmer bottom apparently excluded small burrowing species like the scaphopods. Perhaps the firmer bottom also eliminated Turbonilla. The unusual feeding mechanism of this genus is discussed in Section C of the Systematic Descriptions.

At SP 94, a minor change in bottom character apparently generated a few basic changes in an otherwise normal "35-fathom" fauna.

Temporal Homogeneity

Radiocarbon Dates.- Separate radiometric dating of foraminiferal and shell hash samples from -348.8 to 349.8' in SP 1-B yielded dates of -15,175, ±575, and 15,575, ±575, years before present (Morgan, Coleman, and Gagliano, 1963; 1967). Two determinations of shell hash from -455.5 to 456.5' gave discordant results: 25,250, ±1,450, and +37,000 years. The younger age seems most probable. A lower horizon was dated at 26,500, ±1,450, years. Mudlump faunules clearly differ in age.

Stratigraphic Dates.- Differences in the color of clays facilitate stratigraphic mapping in the Mudlump Province. Data from Morgan (1961, p. 32-33) and Andersen (1961, p. 16-17) show SP 5 and SP 6 faunules are derived from Clay Unit II. Field work incidental to this dissertation and discussion by Morgan, Coleman, and Gagliano (1967) show that faunules from SP 94 also represent Clay Unit II and are from the upper portion of the unit.

The PAL 7 collection was obtained in 1954 and there is no data on the island as it was then developed. Morgan (1961) made a detailed study of PAL 7 in 1949. Fossiliferous sediments were not exposed. Morgan (personal communication) suggests sediments outcropping in 1949 were Clay Unit I,and five years later Clay Unit II was exposed.

Faunal Homogeneity

Assumptions.- Further discussion assumes that key paleobiologic and stratigraphic interpretations discussed above are correct. Faunal comparison seeks to establish the number of soft bottom, open marine, 30- to 35-fathom molluscan communities represented in mudlump faunules. Differences between communities should reflect differences in age. Interpretation assumes that primary, or Linnean, categorical anomalies generate secondary anomalies which limit the utility of faunal comparison. Therefore, greatest emphasis is placed on taxa with normal categorical ratios.

Upper Clay Unit II Faunules.- Rissoid-like microgastropods are rather uniformly distributed throughout upper Clay Unit II faunules (Table 8). SP 1-B faunules are most diverse. Each species present in SP 94 also occurs in SP 1-B. Siphonodentaliids are absent from upper Clay Unit II faunules (Table 9), and pyramidellids are essentially absent (Table 10). Eulimids occur in both faunules (Table 10) but species differ. Pelagic micromollusks are taxonomically diverse in SP 94, and one species occurs in SP 1-B (Appendix 1).

Table 8

COMPARISON OF RISSOID-LIKE MICROGASTROPOD FAUNAS

Taxon	-348.8'	SP 94	-453.3	SP 5	SP 6	PAL 7
Arene lis	2	2		3		8
Alvinia auberiana	1				7	
Zebinella decussata						1
Phosinella cancellata	2			1		5
Zebina browniana						1
Parviturboides interruptus	3	6	3	2	56	
Aorotrema nicholsi	1		1		1	
Elephantanellum imbricatum					14	
Micranellum regulare					49	
Vitrinella meta	1					2
Cerapons simulator	1			2	1	
Circulus pentagonus	1	2	1		2	1
Episcynia inornata						2

Table 9

COMPARISON OF SIPHONODENTALIID FAUNAS

Taxon	-453.3'	SP 5	SP 6	PAL 7
Cadulus cheethami	8			+1,288
Cadulus acus			20	13
Cadulus anderseni				17
Cadulus morgani		2	2	
Cadulus louisianae				1
Cadulus howei			8	43
Cadulus hilgardi	40	2		

Table 10

COMPARISON OF PARASITIC MICROGASTROPOD FAUNAS

Taxon	-348.8'	SP 94	SP 5	SP 6	-453.3	PAL 7
Subfamily Pyramidellinae: species/genera	0	0	0	0	0	3/2
Unique Species	0	0	0	0	0	3
Subfamily Turbonillinae: species/genera	1/1	0	4/1	12/1	1/1	13/1
Unique Species	0	0	0	4	0	6
Subfamily Odostomiinae: species/genera	0	0	0	3/2	0	4/3
Unique Species	0	0	0	0	0	1
Subfamily Chrysallidinae: species/genera	0	0	0	4/1	0	0
Unique Species	0	0	0	4	0	0
Family Eulimidae: species/genera	1/1	1/1	0	1/1	1/1	2/2
Unique Species	0	0	0	0	0	1

Sixty-nine percent of the pelecypods and filter-feeding gastropods in SP 1-B reoccur in SP 94. Forty percent of the large scaphopods and 54% of the carnivorous and herbivorous gastropods of SP 1-B reoccur (Appendix 1). Faunules from SP 94 and from the top of Clay Unit II in SP 1-B are from the same stratigraphic position. Scaphopods are categorically anomalous and the 40% reoccurrence of large forms must be discounted. Remaining macromolluscan taxa suggest that a reoccurrence near 60% is to be anticipated in comparison of categorically sound macromollusks from chronologically and bathymetrically homogeneous mudlump faunules. Comparison of the least diverse benthonic micromolluscan faunule with the most diverse shows a 75% reoccurrence of categorically normal taxa.

Lower Clay Unit II Faunules.- Rissoid faunas of lower and upper Clay Unit II horizons are identical (Table 8). Eulimids are also identical (Table 10; Appendix 1) and pyramidellids are very similar (Table 10). One Turbonilla occurs in each clay unit, but species are different. Pelagic micromollusks are absent from the -453.3 to 456.8' interval, and one specimen occurs in the -472.8 to 473.0' sample (Appendix 1). One of five subsamples of the higher horizon in SP 1-B yielded a pteropod. Pteropods are common in SP 94. Siphonodentaliid faunas differ. Two species occur in the -453.3' unit and siphonodentaliids are absent from the higher horizon.

Eighty-two percent of the macromollusks from -453.3' reoccur in the higher fauna. Two species that do not reoccur are highly specialized carnivoures: Daphnella elata and Vitricythara cf. V.

micromeris. The other nonreoccurring species are small herbivores: Retusa candei and Ringicula cf. R. nitida.

Other South Pass Faunules.- Only micromollusks are known from SP 5 and SP 6. All SP 5 rissoid-like species reoccur in the higher fauna of SP 1-B and 71% of SP 6 species reoccur (Table 8). The two rissoids unique to SP 6 represent a family, the Caecidae, that is absent from all other mudlump faunules. Both SP 5 and SP 6 have two species in the categorically anomalous family Siphonodentaliidae (Table 9). SP 1-B has none. The categorically anomalous pyramidellids occur in great profusion in SP 6, less so in SP 5, and SP 1-B has none (Table 10). All categorically normal micromollusks from SP 5 reoccur in SP 1-B and 55% of the SP 6 fauna reoccurs.

PAL 7 Faunule.- Fifty-seven percent of the rissoid-like gastropod fauna of PAL 7 reoccurs in the higher Clay Unit II fauna of SP 1-B (Table 8). Quantitatively, 80% of PAL 7 rissoid specimens are conspecific with SP 1-B forms. Sixty percent of PAL 7 siphonodentaliids reoccur in other mudlump faunules (Table 9) and half of the eulimids reoccur (Table 10). Three pyramidellinids occur only in PAL 7 (Table 10). Odostomiinids show a 75% reoccurrence, all in SP 6. The subfamilies Chrysallidinae and Turbonillinae are categorically anomalous. None of the Chrysallidinae reoccurs, and 54% of the Turbonillinae reoccur.

Comparison of macromollusks is essentially a comparison with SP 94, the only other faunule with an abundance of large shells. There is a 69% overall reoccurrence and, if large, wide ranging carnivoures

of the family Turridae are discounted, the figure becomes 75%.

Evaluation.- Each mudlump faunule is a small "spot sample" of its community. Stratigraphic study shows that the -348.8' interval in SP 1-B and the SP 94 sample are equivalent. Palinspastic reconstruction is not now possible within the Mudlump Province, but locations are less than a half-mile apart in modern geography, and it seems improbable that original separation exceeded a mile. Comparison is hindered by differences in the volume of samples available and in the mode of collection. SP 94 is a large outcrop sample and SP 1-B is a relatively small sample from a core. The smaller, subsurface sample could not possibly contain a diversity of large forms.

General paleobiologic considerations suggest similar depositional environments, though SP 1-B may have been as much as 30 feet shallower and SP 94 received slightly more energy. Differences are relatively minor.

Categorically normal mollusks from these localities show a 60 to 75% specific level similarity and this is here taken as an indication of the normal variation between small samples of a single molluscan community.

Other mudlump faunules show comparable variation in the reoccurrence of categorically normal mollusks. All faunules are thus considered part of a single community.

CATEGORICAL RATIOS

Analysis suggests that mudlump faunules of all ages represent a single molluscan community developed on soft to fairly firm bottoms in 30 to 35 fathoms of water. Heterogeneities within the community reflect local, small-scale variation in the physical environment. These are analogous to the mosaic of microhabitats Elton (1946) noted within small ecological communities. Thus, the mudlump micromolluscan community should have a categorical ratio near Elton's average of 1.14 for marine communities. The observed figure is 2.25, considerably beyond Elton's 1.63 maximum for small ecological communities. To localize anomalies within the mudlump micromolluscan community, ratios for individual familial level units are catalogued in Table 11.

Evaluation

At the beginning of this report, data compiled by Elton (1946) were discussed as though they were an adequate statement of normalcy in faunas from small ecological communities. This must now be assessed.

Elton's data have several undesirable characters. Faunas were not randomly selected. Microscopic organisms were excluded. The quality of identifications and uniformity in the quality of identifications are open to question. Nomina aperta required subjective treatment. Each small ecological community is the aggregate of countless microhabitats, and these, not the community as a whole, are the rational units of ecology.

Table 11

CATEGORICAL RATIOS

MUDLUMP MICROMOLLUSCAN COMMUNITY

Taxon	Genera	Subgenera	Species	Ratio
Siphonodentallidae	1	3	7	7
Liotiidae	1		1	1
Rissoidae	1		1	1
Rissoinidae	3		3	1
Parviturboididae	2		2	1
Caecidae	2		2	1
Vitrinellidae	4		4	1
Eulimidae	3		3	1
Pyramidellinae	2		3	1.50
Turbonillinae	1	2	20	20
Odostomiinae	3		4	1.33
Chrysallidinae	1	2	4	4

Average: 2.25 species per genus.

Elton (1946) acknowledged most of the limits of his data. He interpreted the general pattern of categorical relationships as evidence that interspecific competition exerts a strong control over the structure of organic communities.

Williams (1947) re-examined Elton's data. He treated it quantitatively and showed that it did not support Elton's conclusions. He suggests, on the basis of Elton's data, that congeneric species are most likely to occur together.

Bagenal (1951) tried to reconcile opposing views. He concluded that Williams' study drew attention to the diversity of microhabitats and that Elton offered a suitable explanation for the near regularity of data.

Further study led Williams (1954) to conclude that Elton's data are nearly random. Re-evaluation by Elton (In Elton and Miller, 1954) led him to conclude that his data are open to many interpretations.

Harper et al. (1961) provide a rather recent re-evaluation. They conclude that Elton and Bagenal were substantially right. They also point out that seral succession demonstrates non-random processes in community formation.

All of this literature is relevant to the present study. All are critical references because, and only because, they accept Elton's data. Great attention has been paid to shortcomings, but critics respect the data themselves. They devoted part of their lives to further study.

Elton's analysis is part of the basic data of ecology. Theoretical implications are debatable, but data themselves provide an approximate standard for normalcy in small ecological communities.

Before comparing mudlump micromolluscan categorical ratios with Elton's norm, it is necessary to exclude one group. Pelagic micromollusks are part of the mudlump fauna but are not part of the benthonic mudlump micromolluscan community. Pelagics belong to one or more planktonic communities characterized by similarity in zoogeographic distribution, in rate and range of diurnal migration, and in other characters not evident in fossil faunas.

Inspection of Table 11 shows that all herbivorous micromollusks in the mudlump community conform to Elton's most frequently encountered ratio: 1 species/1 genus = 1. Apparently, the herbivorous element is shaped by the same forces that control Linnean categorical ratios in Elton's macroinvertebrate communities.

Parasitic taxa show diverse ratios. Eulimidae, Pyramidellinae, and Odostomiinae are approximately normal. The Chrysallidinae have four and the Turbonillinae have 20.

If Siphonodentaliidae, Turbonillinae, and Chrysallidinae are excluded from consideration, the categorical ratio for the mudlump micromolluscan community becomes 1.11. Elton's average for marine communities is 1.14. It thus appears that the mudlump micromolluscan community has an essentially normal categorical ratio, but that selected elements in the community are very abnormal.

Anomalies

As stated in the introduction, there are two general explanations for abnormal categorical ratios.

- Ratios are shaped by different forces from those which control ratios of other forms.
- Categorical units used in classification are not comparable to those used in other groups.

Any discussion of categorical ratios assumes sound and comparable categorical units. Thus, a possible incomparability in categorical units is the most basic of the two possible sources of anomaly.

Categorical Units.- Joysey once observed that, "Classification is based partly on the interest we have in particular animals, and partly on our ability to see differences between them." (Joysey, 1956, p. 83).

Morphological simplicity of some micromollusks lessens the number of conchological characters in which differences can be distinguished. Small size has always strained the standard optical aids of the conchologist. No micromolluscan group has ever been a focus of widespread interest. Clearly, Joysey's statement calls attention to some prime sources of problems in micromolluscan classification.

A second prime problem in the classification of micromollusks arises from similarities in phyletic history. Each lineage has, apparently, been subject to strong and long-continued selection pressure favoring small size and concomitant bionomic adaptations. Where phylogeny is fairly well known, parallelism and convergence are also known. Examples are more fully discussed in Systematic Descriptions.

In the rissoid stock, the best known micromollusks, Parviturboides is a mesogastropod analogue of the archaeogastropod Parviturbo: Skeneopsis and Skenea are similarly related: Circulus and Tornus are parallel but familially distinct rissoids; each is convergent with Paleozoic Helicotoma and Mesozoic Discohelix.

Parallelism is also known in the Siphonodentaliidae and is probably widespread. Cadulus (Gadila) iota Henderson and C. (Gadila) minusculus Dall are essentially similar to small species of Sulcogadila described in this dissertation. Cadulus (Gadila) acus Dall, Cadulus (Platyschides) hilgardi Corgan, new species, and Cadulus (Polyschides) foweyensis Henderson appear to be parallel.

The categorical anomaly in Siphonodentaliidae is an anomaly in one of the two primary subdivisions of a class of animals. In most classes of animals, skeletal characters are not the sole guide to taxonomic diversity within a class. Anatomical differences, ecological differences, even differences in rates of evolution permit a more meaningful, a more natural, subdivision of the class.

Anatomy within the class Scaphopoda is remarkably uniform, though there are major differences in foot morphology and radulae (Henderson, 1920; Emerson, 1962). These may indicate differences in mobility and diet, but, apparently, possible relationships have not been evaluated.

Two studies of feeding in scaphopods are based on direct observation (Morton, 1959; Dinamani, 1964). Both use large dentaliids studied under unnatural conditions. They appear to be the only sources of observational data on scaphopod ecology.

Ecology is unknown, phyletic divergence is slight, anatomy shows little variation; thus, conchology is the only guide to detailed classification. Available classifications consider external characters of the shell. Systematic descriptions in this report show that shell structure is variable within scaphopods and that differences in shell structure may characterize, or help to characterize, familial and generic-level taxa. Scaphopod classification is thus not as broadly based as it might be. It fails to involve characters which appear to have prime taxonomic significance.

There are other undesirable aspects to current classifications of scaphopods. The antiquity of a taxon is, or can be, a character of importance in determining its categorical rank. Current classification of Scaphopoda (e.g. Ludbrook, 1960; Emerson, 1962) assigns subgeneric status to non-transitional taxa distinct for 100,000,000 or more years.

With the cadulid stock, opacity bands are a prominent feature of many species. Their origin is unexplained and a definitive evaluation of their taxonomic significance is thus not possible.

Finally, parallelism is known in cadulids. Small forms of diverse lineages have apparently developed in response to essentially similar selection pressures.

When all these points are considered, it seems probable that the categorical anomaly in mudlump scaphopods is influenced by inadequacies of classification.

Categorical anomalies in Turbonillinae and Chrysallidinae are quite different from those in Siphonodentaliidae. They are

anomalies within subfamilies of a class that is divided into scores of families that yield normal categorical ratios. Genera are discussed at length in Systematic Descriptions. Parallelism is noted. Critical characters like protoconch coiling and prominence of columellar plications are not accorded great significance in current classifications. Still, genera are broadly based. Diagnoses involve both anatomical considerations and a multiplicity of conchological characters.

In addition to conchological differences, review of Systematic Descriptions shows that groups within Turbonilla differ in intrageneric population structure: in patterns of distribution of abundance of individuals. The 11 species of Turbonilla (Turbonilla) have been assigned to super-specific groups characterized by a dichotomy in protoconch character. Three species with a high spired protoconch are known from an average of 2.3 localities. Most occurrences yield more than one individual. The second group has a low spired protoconch. It is represented by a single individual in most occurrences and the six species are known from an average of 1.2 localities. It seems probable that these two morphologic groups have different ways of life. Laws (1937a) treated them as genera.

Seven mudlump species are run of the mill Turbonilla (Pyrgiscus). Five are known from a single occurrence and the seven average 1.3 individuals per occurrence. There is an obvious similarity to the second group in Turbonilla (Turbonilla).

Two mudlump Turbonilla (Pyrgiscus) are quite morphologically distinct: one has tabulated whorls and the other has a parietal tooth.

Each is known from two localities and they average 17 individuals per occurrence.

Except for Laws (1937a), classification of turbonillids generally emphasizes differences in sculpture and de-emphasizes differences in protoconch character. Analysis of mudlump Turbonilla suggests that this may not be correct.

In the mudlump fauna, there is a rather clear break between Turbonilla with high spired and low spired protoconchs. In addition to morphologic differences, they have different abundance patterns that suggest a fundamental difference in ecology. Morphologically transitional species seem to be fairly abundant in the world fauna and data on distribution of abundance of individuals are not available for the world fauna. Difference in protoconch coiling does not seem to be a valid basis for generic separation. Sculpture is clearly not a valid basis. Though classification of Turbonilla should be re-evaluated, the categorical anomaly here noted in Turbonilla does not appear to arise from a failure of classification.

Comparability of Units.- Analysis of micromolluscan faunules in the section on Faunal Homogeneity showed that species of families with normal categorical ratios tend to occur in many faunules while normal species of other families have patchy distributions.

Though the various species of Siphonodentaliidae are part of the same small ecological community, their distributional patterns are only partly overlapping. Similar morphologic types, like Cadulus acus and Cadulus hilgardi do not occur together.

For herbivorous micromollusks with a species/genus ratio of 1, it appears that the distribution of a species tends to approximate the known distribution of the community. For siphonodentaliids, this is not true.

Wigley (1966) has shown that bottom sediment type exerts a very strong control over the distribution of some large Cadulus. It appears that minor variation in bottom sediment type within the areas of the mudlump micromolluscan community creates a great diversity of cadulid microhabitats. Where conditions are suitable, a species tends to occur in large numbers. Elsewhere, it is virtually absent.

Extreme habitat specificity is believed to be the most significant cause of the categorical anomaly in Siphonodentaliidae. Anomalies in Chrysallidinae and Turbonillinae are quite different.

Elton's data are an adequate standard of normalcy in most faunas but exclude the more specialized ectoparasites. Some of these may have intrageneric population structures fundamentally different from those of other animals. Two classic studies describe the incidence of mallophagous insects on birds (Clay, 1949; 1957). Species/genus ratios over 1.5 are noted on a single bird. Further, six, eight, or more parasitic genera occur on an individual host. Host specificity is high on the specific or generic level, but individuals are vagrant and may change host animals. A fauna of just a few dozen birds could readily yield 50, 60, or more closely related species of parasites.

Categorical ratios in the Turbonillinae and Chrysallidinae are believed comparable to the Mallophaga. Berry (1964) hypothesized

that host specificity is an adequate explanation for the great taxonomic diversity of local pyramidellid faunas. This is a partial explanation. Differences in the duration and location of host-parasite contact, differences in parasite mobility, and differences in the mechanics of feeding are added to host specificity and produce an extreme restriction in the territory occupied by a parasite.

In the mudlump micromolluscan community, most elements have normal categorical ratios. Extreme specialization in habitat and territory appears to account for anomalies in a few groups.

SUMMARY

The term micromollusk is introduced to describe superfamilies in which there is evidence of a phyletic trend toward smaller size and in which representative lineages include species less than 6 mm in maximum adult size.

Fifty-four species of benthonic micromollusks occur in Quaternary faunules from the Mudlump Province of the Mississippi River Delta. They are discussed or described and referred to 24 genera.

The Mudlump Province is defined on structural and stratigraphic grounds. It is that portion of the Mississippi River Delta in which the Quaternary sedimentary sequence permits, or permitted, development of large clay diapirs.

Study of mudlump micromollusks suggests a number of nomenclatorial innovations.

Ontogenetic sculptural changes in Arene lis Corgan, new species, are described in detail, and three previously described Western Atlantic micromollusks are transferred to Arene. They are: Cyclostromella (sic) venezuelana Weisbord, 1962, Cyclostrema cubana Aguayo, 1948, and "Liotia" canimarensis Aguayo and Borro, 1946.

The family Parviturboididae is described as new. The genera Parviturboides and Aorotrema are transferred to the Parviturboididae from the Vitrinellidae. Parviturboides is revised. Three subgenera are recognized: Parviturboides (Parviturboides) Pilsbry and McGinty, type species Cyclostrema sanibelense Pilsbry, Parviturboides (Denseturboides), new subgenus, type species Liotia milium Dall,

and Parviturboides (Polylixia), new subgenus, type species Parviturbo germanus Pilsbry and Olsson.

Authorship of Aorotrema is generally attributed to Schwengel and McGinty (1942). Requisites for authorship were first met by Pilsbry (1953). Aorotrema Pilsbry, type species Cyclostrema pontogenes Schwengel and McGinty, is revised. Aorotrema nicholsi is described as new. Quadrilixia Corgan is described as new, with Aorotrema gardnerae Pilsbry as the type and only species.

Heterostrophy is noted for the first time in the family Vitrinellidae. Cerapons Corgan is described as a new genus of heterostrophic vitrinellids. Cerapons simulator Corgan is the type species. Another heterostrophic species, Vitrinella meta Corgan, is assigned to Vitrinella, itself.

The generic name Esmeralda Pilsbry and Olsson, 1952, is preoccupied. Olsson will offer a replacement name.

Ponocyclus Pilsbry, 1953, is treated as a junior subjective synonym of Circulus Jeffreys, 1865. Comparison of East Coast and West Coast populations shows that the Miocene to Recent Circulus pentagonus (Gabb), 1873, occurs in the faunas of both coasts. A synonymy, in part original, includes Vitrinella tricarinata C. B. Adams, 1852, Skenea trilix Bush, 1885, Adeorbis supranitidus (Wood) Dall, 1889, Circulus cosmius Bartsch, 1909, and Cyclostremiscus glyptomphalus Pilsbry and Olsson, 1952.

The wall structure of cadulid scaphopods is described, apparently for the first time. A pronounced distinction from

dentaliids is noted. The three smallest Western Atlantic Cadulus are redescribed. Opacity banding in cadulids is discussed. One new subgenus, Cadulus (Sulcogadila), and six new species are described.

Data on host preference in the family Pyramidellidae are reviewed and placed in taxonomic order. In general, subfamilies contain species that are similar in range of hosts and, perhaps, in host specificity.

Two new Syrnola are described: S. ampla and S. meridiana. Type designations of Longchaeus Moerch and Turbonilla Risso are reviewed. Twenty new species of Turbonilla are described.

Telloda Hertlein and Strong, 1951, and Folinella Dall and Bartsch, 1904, are junior objective synonyms of Eulimastoma Bartsch, 1916, and Amoura Folin, 1873. Eulimastoma harbisonae Bartsch, 1955, is considered a junior subjective synonym of Eulimastoma olssoni Bartsch, 1955. Eulimastoma vetula Corgan is described and named. Eulimastoma sp. A, known only from juveniles, is also described as new.

Kilatus Corgan is proposed as a new genus of odostomiids. Kilatus pondella Corgan, new species, is the type species. Odostomia weberi Morrison, 1965, is transferred to Kilatus.

Besla Dall and Bartsch, 1904, is recorded in the Atlantic for the first time. Besla varia Corgan, new species, is described.

Type designations of Chrysallida Carpenter, 1856, are discussed. Four species of Chrysallida are described. Two are clearly new. Fargoa Bartsch, 1955, is treated as a subgenus of Chrysallida

and Odostomia (Menestho) beauforti Jacot, 1920, is transferred to Chrysallida.

In all discussions of pyramidellids, an attempt is made to evaluate unillustrated species. Each pertinent unillustrated taxon is discussed in appropriate detail.

A total of one new family, six new generic level taxa, and thirty-five new species is formally described. New generic or subgeneric combinations are advanced for 17 species.

There is a 69% incidence of new species. No new taxa were noted in the Eulimidae, Caecidae, Rissoidae, or Rissoinidae. This is unusual for occurrence of these families in the northern Gulf of Mexico has never been described. The most proximate reference faunas are from Florida and the Antilles.

In the Siphonodentaliidae, 86% of mudlump species are new. Between 1920 and the present, two descriptive papers treated Gulf of Mexico-Caribbean scaphopods (Clench and Aguayo, 1939; Emerson, 1952). Processing of samples from pre-1920 dredgings excluded very small forms (Henderson, 1920, p. 135). Two mudlump species are under 2 mm in maximum size. Two are the smallest Western Atlantic species of their subgenera. Habitat specificity of cadulids and a lack of prior study appears to account for the high incidence of new taxa.

One new liotiid is described, and it is the only species of its family. In the Parviturboididae and Vitrinellidae, 50% of the species are new. Western Atlantic vitrinellid-like mollusks were essentially undescribed prior to Pilsbry and McGinty (1945a-1950) and they dealt with the Floridan fauna. Moore (1964a; 1965) reviewed

these and noted three new forms, principally from outside Florida. Weisbord (1964) had a 100% incidence of new species in a ten-species Neogene fauna from Venezuela and Altena (1966) had 60% in a five-species Quaternary fauna from Surinam.

Except for modern faunas of Florida and the Bahamas, the Gulf of Mexico-Caribbean vitrinellid and liotid faunas are poorly known. The observed incidence of new taxa seems smaller than might be expected.

There has been one small-scale study of northern Gulf of Mexico pyramidellids (Morrison, 1965). Bottom sediment type and host specificity strongly influence pyramidellid distribution. These and lack of prior study partially explain a 90% incidence of new species, but much of the explanation lies in the "normal" pattern of pyramidellid speciation. High endemism seems to be a taxonomically significant character of the family. Incidence of new species in some rather well-known pyramidellid faunas is shown in Table 1. Each author could draw on a wealth of prior descriptions of faunas from the same area. Several papers are museum reviews. The average incidence of new species is 68%.

Mudlump micromollusks are part of an extremely varied fauna. A total of 186 molluscan species are listed (Appendix 1). Consideration of environment of deposition and specific composition suggests that mudlump molluscan faunules are homogeneous and represent a single molluscan community developed in a small geographic area on soft to fairly firm bottoms in 30 to 35 fathoms.

Elton (1946) compiled data on ratios of genera to species

in macrofaunal communities from similarly restricted geographic and ecologic settings. Comparable data for micromolluscan communities (Table 1) show anomalously high categorical ratios.

Three elements in the mudlump micromolluscan community have divergent categorical ratios. Probable causes can be suggested. Apparently, forces shaping the remainder of the micromolluscan community of the Mudlump Province are identical with those which produce the normal structure of macroinvertebrate communities.

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SYSTEMATIC DESCRIPTIONS

Phylum MOLLUSCA Cuvier, 1797

1797. Mollusques CUVIER, Tableau elementaire de l'histoire naturelle des animaux, p. 372.

Diagnosis.- Animals without a true endoskeleton, with the body generally coated by slime or mucous; body, at some ontogenetic stage, divisible into four gross anatomical regions, a head, a foot, a visceral mass, and a sheet of glandular tissue, the mantle, which in most species secretes a calcareous shell formed within an organic matrix.

Morphologic Terms.- The mollusks have been a focus of intense study for several centuries and a familiarity with the essential features of the phylum is part of the background of virtually every person interested in the biological or earth sciences. It is therefore unnecessary to define each morphologic term used in the description of mollusks. Uncommon and new terms are defined when first used. For other definitionsthe reader is referred to comprehensive glossaries by Arnold (1965), Burch (1950), and Cox (1960).

Abbreviations.- The following standard abbreviations are used in discussion of type and reference specimens:

ANSP: Academy of Natural Sciences of Philadelphia collection number.

CAS: California Academy of Sciences collecting locality number.

LSUDGMTC: Louisiana State University, Department of Geology Museum type collection number.

MCZ: Museum of Comparative Zoology, Harvard University, collection number.

USFC: United States Fish Commission collection number. Equals USNM.

USNM: United States National Museum collection number.

Type Material.- Holotypes and paratypes of all new species described in this report are in the type collection of the Louisiana State University Department of Geology Museum. Numbers assigned to holotypes and illustrated specimens are part of text description. All numbers assigned unillustrated specimens are listed in Appendix 2.

Text Arrangement.- This report is based on two taxonomies: the conventional hierarchy of systematic zoology and a division of the Phylum Mollusca into micromollusks and non-micromollusks. Arrangement of systematic descriptions follows both taxonomies. Cadulids, rissoids, and pyramidellids are described separately.

SECTION A: CADULID SCAPHOPODS

General Comments

Mudlump Fauna.- Approximately 1,455 specifically determinate Cadulus were examined. Seven species are represented. One is tentatively identified with an established taxon and three established taxa are redescribed to facilitate comparison with mudlump species. Six species and one subgenus are described as new.

Classification.- Extreme morphologic simplicity limits current classifications to consideration of a very few morphologic characters. Apical structure has long been the prime guide to subgeneric placement in Cadulus. It is the only well-studied aspect of cadulid morphology that seems to indicate phyletic place. The fossil record of cadulids shows a rational pattern of branching (Emerson, 1962; Ludbrook 1960) and the significance of apical characters seems proved. A classification of Cadulus is given in Table 12.

Though the current classification of Cadulus and cadulids is simple, the potential basis for conchological classification is far from exhausted. Two little-studied aspects of cadulid morphology, opacity banding and shell structure, are briefly discussed below.

Opacity Bands.- Bands of alternating more-opaque and more-translucent shell are here called opacity bands. They are defined ostensively by reference to plate illustrations of Cadulus howei.

Individual opacity bands conform to and are, in general, clearly delimited by growth lines. In most species, a number of growth lines occur within an opacity band. Rings of more chalky and

Table 12

KEY TO THE SUBGENERA

OF CADULUS[1]

A. Apex simple

1. Surface smooth

a. Small, obese, inflated near the middle: Cadulus

b. Small to large, not obese, inflation medial or anterior: Gadila

2. Surface not smooth

a. Large; striae longitudinal: Striocadulus

b. Small to medium sized, elongate; striae concentric: Gadilopsis

B. Apex sculptured

1. Apex with prominent slits, appears chiseled-out

a. Two prominent lateral slits: Dischides

b. Four prominent slits: Polyschides

2. Apex with inconspicuous, smoothly rounded, notches

a. Two lateral notches: Sulcogadila, new subgenus

b. Four notches: Platyschides

[1]After Woodring (1925), Ludbrook (1960), and Emerson (1962).

less chalky shell appear to be a fossil manifestation of opacity banding. Unaltered bands are best observed in lustrous specimens.

Monographic studies of cadulids generally note translucent rings. For example, Emerson (1962, p. 477) characterizes Cadulus as "...texture of shell vitreous and more or less translucent or transparent, vitreous surface often modified by circular deposits of shelly material, causing alternate rings of translucency..."

In new species of mudlump Cadulus, banding cannot be attributed to variation in shell thickness. Thickness is uniform and bands are not apparent in thin-section or whole-specimen X-ray. Shell structure consists of tubular laminae, uninterrupted from beginning to end. Even in very heavily banded specimens there is no evidence of transverse breaks.

Cadulids examined in thin-section have a diffuse extinction pattern without observable variation in extinction angle. Thus, banding does not seem attributable to a major change in crystallographic orientation. High resolution optical, X-ray, or electron microscope study might show a significant minor variation in aragonite orientation, in the average size of prisms, or in inclusions. Within the scope of the present study, opacity banding in mudlump Cadulus is not explicable.

The mechanism by which banding is produced remains unknown, but the cause of banding seems clear. Since bands are delimited by growth lines, they are related to growth.

Opacity bands in cadulids are analogous to micro-rings formed during the growth of squids (M. Clarke, 1965). A micro-ring is a group of individual growth increments set off from the next younger micro-ring by a minute ledge. Clarke suggests each micro-ring represents one essentially continuous period of growth. Limits of micro-rings are emphasized growth lines that rise above the shell surface. Change in slope of the shell surface causes a banded appearance.

Opacity bands in scaphopods lack sculptural expression but also result from cyclic growth. Each band represents a period of continuous, though intermittent, growth. A resting stage follows and when growth is resumed, shell-forming secretions differ slightly from those laid down before.

Earlier workers have not treated opacity banding as a taxonomically significant character. Yet it is a prominent feature of many cadulids and Henderson (1920) clearly shows that banding is present in some species, absent in others, and that prominence of banding may vary with ontogenetic stage.

Banding characters are taxonomically significant aspects of morphology, roughly comparable to variations in color, number of ribs, or thickness of shell. Where present, opacity banding is described in all practical detail.

Shell Structure.- Apparently, the shell structure of siphonodentalid scaphopods has never been described. Only dentalids are mentioned in the two standard references on scaphopod shell structure (Bøggild, 1930; Couvreur, 1929). Dentalid shells have three or more layers.

In Cadulus (Gadila) and Cadulus (Sulcogadila) the wall structure appears to be completely undifferentiated. There is an extremely thin external layer, a periostracum, but the bulk of the wall is composed of simple laminae that are not arranged in higher order groupings.

Cadulus (Platyschides) appears quite different. In addition to the periostracum, there are two distinct shell layers. The inner layer is thinnest and the overall structure seems analogous to that in the Dentaliidae.

Study of scaphopod wall structure in this dissertation is not a definitive treatment of the subject. It is designed to provide a more adequate characterization of taxa and to assess the prospective contribution of shell structure studies to knowledge of cadulid phylogeny. The prospective contribution appears to be great, but a full evaluation lies beyond the province of a micromolluscan study.

Class SCAPHOPODA Bronn, 1862

1862. Scaphopoda BRONN, Klassen und Ordnungen der Weichthiere, v. 3, abt. 3, opp. p. 523.

Diagnosis.- Mollusks with bilateral symmetry, with an external tubular shell which is posteriorly attenuated and open at both ends.

Family SIPHONODENTALIIDAE Simroth, 1894

1894. Siphonodentaliidae SIMROTH In Bronn, Klassen und Ordnungen des Thier-Reichs, ser. 2, v. 3, p. 354.

Diagnosis.- Scaphopods with central tooth of radula almost square; size minute to fairly large; rarely sculptured; apertural area commonly constricted.

Genus CADULUS Philippi, 1844

1844. Cadulus PHILIPPI, Enum. Moll. Sicil., v. 2, p. 209.

1962. Cadulus Philippi: EMERSON, Jour. Paleontology, v. 36, p. 476.

Type Species.- By monotypy, Dentalium ovulum Philippi.

Diagnosis.- Siphonodentaliidae with contracted aperture; generally inflated; surface usually smooth, rarely annulated or longitudinally striate; cross-section circular to oval; small to medium size.

Wall Structure.- Ontogenetic variation in wall structure is unknown

and the structure of most subgenera remains undescribed. When more data are available, wall structure may be a guide to revision of the genus. In the interim, wall structure is treated as a subgeneric character.

Identification Problems.- Description of Cadulus from mudlump faunules requires evaluation of all comparable Western Atlantic Neogene and Recent taxa. Two specific level taxa cannot be recognized from published data, a third has never been illustrated, and re-evaluation of a fourth suggests a new subgeneric identification.

Clear concepts of these critical taxa are prerequisite to understanding the mudlump fauna. Types were re-examined. An extended discussion is given in Appendix 3.

CADULUS (GADILA) Gray, 1847

1847. Gadila GRAY, Proc. Zool. Soc. London, 1847, p. 159.

1865. Helonyx STIMPSON, Amer. Jour. Conch., v. 1, p. 63.

1882. Loxoporus JEFFREYS, Proc. Zool. Soc. London, 1822, p. 664.

1962. Gadila EMERSON, Jour. Paleontology, v. 36, p. 478.

Type Species.- By original designation, Dentalium gadus Montagu.

Diagnosis.- Cadulus with simple apical orifice; shell more or less strongly curved; generally with medial or anterior inflated area; tapering toward apex and aperture; apex smooth, wall structure of simple laminae that are not compounded into groups of higher order.

Cadulus (Gadila) cheethami Corgan, new species

Plate I, Figures 1-6; Plate XIV, Figures 1,4-5

Description.- Cadulus (Gadila) of extremely large size; strongly curved; slender; with appreciable dorso-ventral flattening of the aperture; greatest diameter in anterior third; generally with strong opacity banding throughout ontogeny; largest observed individual slightly over 18.2 mm with a maximum diameter of 2 mm, aperture 1 x 1.3 mm, and apex with a .3 mm orifice; average individuals between 13 and 16 mm.

Comparisons.- Careful study of 296 perfect specimens shows that 81.1% have a simple apex, 16.3% have a dorsal notch, and 2.6% have both dorsal and ventral notches. Ventral notches are fairly deep and occur only in dorsally notched individuals. Most dorsal notches are very deep. The normal apex of Cadulus cheethami is clearly the simple apex of Gadila. Abnormal or atypical apices are common in all scaphopods, a phenotypic variation induced by sediment clogging.

No Western Atlantic Recent or fossil Cadulus (Gadila) approaches C. cheethami in size or general conformation. The only species at all comparable is Cadulus greenlawi Henderson, 1920. This species is treated at length in Appendix 3.

Large Cadulus cheethami are half again as large as the only known specimen of C. greenlawi but size differences have little meaning unless large populations are known. Significant differences are the stronger curvature and greater dorso-ventral compression of C. cheethami.

Cadulus (Gadila) greenlawi and C. cheethami appear to form a distinct group: a stock of gigantic, dorso-ventrally compressed Gadila that retain opacity banding throughout ontogeny. Superficially, Cadulus (Platyschides ?) elongatus Henderson seem to be part of this group. The holotype, USNM 323596, was long the only known specimen, and its damaged apex weakly suggests reference to Gadila. Recently, Turner (1955) recorded five new specimens and made a firm subgeneric identification. It is thus not part of the C. greenlawi stock.

Remarks.- Whole-specimen X-ray photographs of strongly opacity banded and weakly opacity banded Cadulus cheethami are compared in Plate I. There is no discernible difference and no difference can be noted in comparison of thin-sections of weakly banded and strongly banded specimens. This is part of the evidence which suggests that opacity banding in scaphopods is not a byproduct of changes in shell thickness.

Origin of Name.- In honor of Dr. Alan H. Cheetham, student of the mud-lump fauna and my professor of Invertebrate Paleontology.

Occurrence and Abundance.- SP 1-B, -456.55 to 456.75' (1 broken adult, 7 apical fragments); PAL 7 (picking stopped with 788 good specimens and 500 or more fragments, very young specimens appear to be absent from this population).

Holotype.- LSUDGMTC 7471.

Figured Specimens.- LSUDGMTC 7464-7465; 7468-7471.

Cadulus (Gadila) acus Dall, 1889 ?

Plate II, Figure 1

1889. Cadulus acus DALL, Bull. Mus. Compar. Zool., v. 18, p. 432, pl. 27, fig. 11.

Description.- Cadulus (Gadila) with greatest diameter immediately posterior to aperture, without distinct inflation; circular in cross-section; with abundant, prominent, narrow opacity bands throughout ontogeny; slightly curved to acicular; narrow; apical orifice small, about .12 mm; size to 8 x .75 mm.

Remarks.- The anterior inflation and aperture are separated by a millimeter or two and, in this region, the shell is thin. The chance of collecting a perfect specimen is thus slight.

Very slender, straight or slightly curved cadulid fragments occur in the mudlump fauna and cannot be assigned to any species represented by an intact adult. Apical characters require reference to Gadila and specimens are comparable to the apical portion of individuals labeled Cadulus acus in the collection of the U.S. National Museum. Identification is questioned pending collection of an intact adult.

Cadulus acus has been referred to the subgenus Gadilopsis Woodring (Emerson, 1952) but lacks the annulae characteristic of Gadilopsis.

Occurrence and Abundance.- SP 6 (20 apical fragments); PAL 7 (13 apical fragments).

Geographic Distribution.- Cadulus acus Dall. Bahamas, Antilles, and Central America.

Bathymetric Range.- Cadulus acus Dall. 5 to 274 fathoms.

Figured Specimen.- LSUDGMTC 7366.

CADULUS (SULCOGADILA) Corgan, new subgenus

Type Species.- Here designated, Cadulus (Sulcogadila) anderseni Corgan, new species.

Diagnosis.- Cadulus with two shallow lateral apical grooves and corresponding dorsal and ventral lobes; without sculpture; apex dorsoventrally compressed; aperture laterally compressed; size small to microscopic; wall structure simple, of concentric laminae that are not compounded into layers of higher order.

Content.- Two species are definitely referable to Sulcogadila: Cadulus (Sulcogadila) anderseni Corgan, new species, and Cadulus (Sulcogadila) hilgardi Corgan, new species.

Two additional species can be referred to Sulcogadila (?). Each is known from a single specimen and neither has a perfect apex. They are Cadulus (Gadila) iota nanus Clench and Aguayo, 1939, and Cadulus (Sulcogadila ?) louisianae Corgan, new species.

Comparisons.- Sulcogadila is compared with other subgenera of Cadulus in Table 12.

Remarks.- Species referred to Sulcogadila, new subgenus, resemble small Cadulus (Gadila). The two subgenera seem closely related but the apical morphology of Sulcogadila is distinctive.

The original content of Platyschides Henderson (1920, p. 104) included species with either two or four apical grooves but no nominal Platyschides has bilateral grooves and none shows a change in compression.

Shell structure is known in Cadulus (Sulcogadila) anderseni and seems indistinguishable from the structure of Cadulus (Gadila) cheethami. Cadulus (Platyschides) howei is distinctly different.

Apertural compression is never strong in known Sulcogadila. It may not be an essential character of the subgenus.

Origin of Name.- Sulcogadila draws attention to the apparent close relationship to Gadila and to the apical sulcae, or grooves, which are one distinguishing feature of the taxon. The name Gadila, itself, has no apparent meaning. The prefix is from the Latin sulcus, a furrow.

Cadulus (Sulcogadila) anderseni Corgan, new species

Plate IV, Figures 1-4

Description.- Cadulus (Sulcogadila) with medial inflation; with gentle curvature; generally with a few opacity bands in apical region; approximately symmetrical about the middle; dorsal and ventral profiles smooth, without bulbous expansion; circular in medial cross-section, apex with marked dorso-ventral compression, aperture with gentle lateral compression.

maximum size about 1.70 mm, greatest diameter .50 mm, aperture with internal diameter of .28 x .26 mm, apex with internal diameter of .14 x .20; apex relatively thick, without internal callosity; generally without opacity bands.

Comparisons.- All comparable species are redescribed in Appendix 3. Most differ fundamentally in apical character.

Cadulus nanus Clench and Aguayo is probably a Sulcogadila and resembles C. anderseni in size. It differs in growth form. The inflation is anterior, rather than medial, and the apex is broader.

Remarks.- Cadulus anderseni is the smallest Western Atlantic Cadulus.

Origin of Name.- In honor of Dr. H. V. Andersen, pioneer student of mudlump faunas.

Occurrence and Abundance.- PAL 7 (17).

Holotype.- LSUDGMTC 7378.

Figured Specimens.- LSUDGMTC 7378-7379.

Cadulus (Sulcogadila) morgani Corgan, new species

Plate IV, Figures 9-10

Description.- Cadulus (Sulcogadila) without medial inflation; without distinct opacity bands; with gentle curvature throughout; circular in medial cross-section, apex with very strong dorso-ventral compression, aperture with gently lateral compression; maximum size about 1.96 mm,

maximum diameter .48 mm; apex .18 x .30 mm, aperture .30 x .28 mm.

Comparison.- No Western Atlantic Cadulus is similar to Cadulus morgani Corgan, new species. The minute Cadulus anderseni Corgan, described above, seems most closely related. It differs in presence of a medial inflation and the lesser compression of the apical orifice.

Origin of Name.- In honor of Dr. James P. Morgan, foremost student of the mudlump islands.

Occurrence and Abundance.- SP 5 (2); SP 6 (2).

Holotype.- LSUDGMTC 7455.

Figured Specimen.- LSUDGMTC 7455.

Cadulus (Sulcogadila ?) louisianae Corgan, new species

Plate IV, Figures 2, 6

Description.- Cadulus of moderately small size; slightly curved; with moderate anterior inflation which interrupts the dorsal profile; inflation nearer middle than aperture; apex dorso-ventrally compressed; aperture laterally compressed; medial cross-section rounded; with poorly developed opacity bands in the apical region; length 4.36 mm (apex slightly broken), width .98 mm, apex .32 x .40 mm, aperture .60 x .54 mm, known only from holotype.

Comparisons.- Since the apex of Cadulus louisianae is not known, a definite subgeneric reference seems inadvisable. Comparison is,

necessarily, principally with species of Sulcogadila since these are the only small cadulids in which compression changes from dorso-ventral to lateral. Cadulus louisianae Corgan, new species, is much larger than Cadulus morgani Corgan, the largest unquestioned Sulcogadila. It also differs in presence of a medial inflation which is absent in C. morgani. Among Gadila, C. louisianae is most reminiscent of Cadulus mayori Henderson, but this species lacks compression and generally has a callosity within the apical orifice.

Remarks.- Though Cadulus louisianae is known from a single imperfect specimen, it is very distinct and can be characterized well enough to insure recognition by future workers.

The changed from dorso-ventral to lateral compression strongly suggests reference to Sulcogadila; however, subgeneric reference is questioned since the apex is unknown. The apical shell of this species is very thin and the chance of finding a perfect specimen is less than in most species of Cadulus.

Origin of Name.- From the State of Louisiana.

Occurrence and Abundance.- PAL 7 (1)

Holotype.- LSUDGMTC 7339.

CADULUS (PLATYSCHIDES) HENDERSON, 1920

1920. Cadulus (Platyschides) HENDERSON, U.S. Nat. Mus. Bull. 111 p. 104.

1962. Cadulus (Platyschides) Henderson: EMERSON, Jour. Paleontology, v. 36, p. 479.

Type Species.- By original designation, Cadulus grandis Verrill.

Diagnosis.- Cadulus with four broad, shallow apical notches; greatest inflation anterior to the middle; generally with slight dorso-ventral flattening at aperture and apex; without sculpture; wall structure trilamellar.

Remarks.- Wall structure is known only in one species of Platyschides: Cadulus howei Corgan, new species, described below. This species seems fairly representative of Platyschides and its wall structure is quite distinct from Cadulus (Gadila) cheethami and C. (Sulcogadila) anderseni, the only other Cadulus in which wall structure is known.

Differences suggest generic or subfamilial distinction.

Cadulus (Platyschides) howei Corgan, new species

Plate III, Figures 1, 3-4

Plate XIV, Figure 2

Description.- Cadulus (Platyschides) with a symmetrical apex, notches and lobes equal and opposite; moderately curved growth form, with prominent growth lines; shell thickness very variable, perhaps reflecting

age, generally thick shelled; all specimens show opacity banding which persists throughout ontogeny; maximum adult size fairly uniform, about 3.40 mm in length, width about .86 mm, and apertural diameter of .62 x .54 mm, maximum external apical diameter of about .46 mm and a maximum internal apical diameter of about .24 mm.

Comparisons.- The many perfect apices of C. howei are textbook examples of Platyschides. Cadulus howei is, by far, the smallest Western Atlantic Platyschides. It most resembles Cadulus (Platyschides) miamiensis Henderson, 1920, which is almost 8 mm in length and more strongly curved. In size, C. howei most resembles C. nitidus Henderson and C. amiantus Dall, each 5.75 mm long, but these species differ in growth form.

Remarks.- The wall structure of Cadulus howei,described in the diagnosis of Platyschides and illustrated in Plate XIV, is quite distinctive. The specimen illustrated in axial thin-section shows strong opacity banding which is not apparent in the thin-section. This is part of the evidence which suggests that opacity banding does not reflect changes in wall thickness.

Origin of Name.- In honor of Dr. H. V. Howe, pioneer professor of micropaleontology and authority on the geology of the Gulf Coast.

Occurrence and Abundance.- PAL 7 (53); SP 1-B -350.9 to 351.1 (1 questionable); SP 6 (8).

Holotype.- LSUDGMTC 7451.

Figured Specimens.- LSUDGMTC 7451-7452, 7466.

Cadulus (Platyschides) hilgardi Corgan, new species

Plate III, Figures 2,5

Description.- Cadulus (Platyschides) with lobes more prominent than notches; curvature more pronounced in juvenile than adult; growth form elongate-acicular, very slowly expanding; growth lines strongly inclined; cross-section rounded throughout; inflation adjacent to aperture, apertural rim thin and delicate; length of largest specimen about 5.32 mm; maximum width about .56 mm; internal diameter of aperture about .53 mm; external diameter of apex about .28 mm, internal diameter of apex about .24 mm, apex not thickened.

Comparisons.- The anterior inflation makes Cadulus hilgardi unique among Western Atlantic Platyschides. In this character it resembles several nominal species of Polyschides, like Cadulus quadridentatus Dall and C. acompsus Henderson, but these species have incised apical slits rather than the rounded grooves of C. hilgardi. Among Polyschides, C. hilgardi most resembles C. foweyensis Henderson, but this species has the inflation well removed from the aperture.

Remarks.- If subgeneric units in Cadulus are phyletically sound, the gross form of Cadulus hilgardi must have great adaptive significance

for similar forms have evolved in most lineages of unsculptured Cadulus. Cadulus acus Dall is much less curved in the juvenile but is otherwise an analogue in Gadila. As noted in the comparison, above, C. acompsus Henderson and C. quadridentatus Dall are analogues in Polyschides.

Distribution records, given below, suggest that Cadulus hilgardi lives in dense local populations.

Origin of Name.- In honor of Dr. Eugene W. Hilgard, pioneer Gulf Coast Geologist.

Occurrence and Abundance.- SP 1-B, -456.3' (5), -456.55 to 456.75 (14), -456.75 to 456.95 (21); SP 5 (2).

Holotype.- LSUDGMTC 7456.

Figured Specimens.- LSUDGMTC 7456-7457.

SECTION B: RISSOIDS AND SIMILAR MICROGASTROPODS

General Comments

Mudlump Fauna.- Herbivorous microgastropods of the superfamily Rissoacea s.l. are fairly abundant in mudlump faunules. Thirteen species are represented by a total of 188 determinate specimens.

Rissoids are an especially difficult group. Identification required examination of collections in the U.S. National Museum and the Academy of Natural Sciences of Philadelphia. Three new generic level taxa which do not occur in the mudlump fauna are diagnosed to clarify the content of genera present in the mudlump fauna.

Of the 13 rissoids present in the mudlump fauna, 12 are referable to established genera. One genus is described as new. Nine species are identified with established species and four are described as new.

Families Present.- Mudlump faunules contain species of the families Rissoidae, Rissoinidae, Caecidae, Vitrinellidae, and also the family Parviturboididae, new family. The archaeogastropod family Liotiidae resembles the rissoid stock and is treated along with them.

Neontologic Data.- In sections A and C of these systematic descriptions, a unified treatment of morphology, ecology, or other pertinent aspects of neontology is possible. The rissoid stock is so diverse that comparable treatment is not possible. These data are presented at critical points in the hierarchical scheme.

Class GASTROPODA Cuvier, 1797

1797. Gasteropodes CUVIER, Tableau elementaire de l'histoire naturelle des animaux, p. 383.

Diagnosis.- Mollusks in which adult morphology is influenced by torsion--a rotation of the soft parts through a 180° loop, and, generally, the reduction of one unit in each paired organ system; adult animal asymmetrical; with one pair of shell muscles; generally coiled, with a well-developed head and a broad muscular foot.

Subclass PROSOBRANCHIA Milne-Edwards, 1848

1848. Prosobranches MILNE-EDWARDS, Ann. Sci. Nat. Zool., ser. 3, v. 9, p. 107.

Diagnosis.- Gastropods in which results of torsion are evident throughout ontogeny, visceral nerves cross in a figure 8; primitively, head with a single pair of tentacles which may be lost; with esophageal glands; generally coiled, shelled, dioecious, and operculate.

Order ARCHAEOGASTROPODA Thiele, 1925

1925. Archaeogastropoda THIELE, Mollusca In Kuekenthal, W., Handb. Zool., v. 5, p. 74.

Diagnosis.- Prosobranchs in which the left kidney is reduced; genital system simple, without specialized genitalia, with external fertilization; often with indication of bilateral symmetry; primitively with

branched gills; shell bearing, adult shell either limpet shaped or coiled, if coiled generally with either a selenizone or nacreous interior or minute and simple; radula either rhipidoglossate or docoglossate.

Suborder TROCHINA Cox and Knight, 1959

1959. Trochina COX AND KNIGHT, Proc. Malacol. Soc. London, v. 33, p. 263.

Diagnosis.- Archaeogastropods with a nacreous interior shell layer, radula rhipidoglossate.

Family LIOTIIDAE Gray, 1850

1850. Liotiidae GRAY, Fig. Mollusc. Anim., v. 4, p. 88 (as Liotiadae).

Diagnosis.- Trochinids of small to medium size; spirally and axially sculptured; very low spired to trochoid; peristome continuous, generally thickened; sculpture generally coarse; operculum multispiral, with exterior surface of discrete flakes or beads.

Remarks.- The North American liotid fauna is poorly understood and descriptions of species are widely scattered. In the world fauna, liotids are often confused with rissoids of the family Vitrinellidae.

Genus ARENE H. and A. Adams, 1854

1854. Arene H. AND A. ADAMS, Gen. Rec. Moll., v. 1, p. 404.

Type Species.- By subsequent designation, Woodring 1928, Turbo cruentatus Muehlfeld.

Diagnosis.- Liotiids with the periphery angular and nodulous or spinose; spire flat, tabulated; umbilicus deep, spiral cords within umbilicus; sculpture of fine axial riblets and courser spiral plicae or costae, axials develop scalar spines or nodes in a regular pattern.

Arene lis Corgan, new species

Plate V, Figures 1-6

Description.- Arene with very dense, regular, delicate axial microsculpture, each axial microsculptural element appears to be a minute varix which simulates a riblet; spiral macrosculpture of a few, generally six, plicae, which become costae in the adult; axial macrosculpture of aligned, scalar spines or nodes which generally develop on every twelfth microvarix; in the very early juvenile axial microsculpture dominates but the umbilical plication and two or three peripheral plications are present; more mature juveniles have axially aligned nodes which soon give rise to scalar spines, nodes appear first on the umbilical and upper peripheral plication; late juveniles retain all sculpture of earlier stages and add a subsutural canal delimited by a spiral plication; on the body whorl, axial microvarices are generally less pronounced though equally numerous, spiral

sculpture dominates with axial spines generally worn down to rounded bosses, the plication or cord nearest the suture now bears axially elongate spines; periphery with three costae, the lowest less nodular than the others; umbilicus bounded by a scalar cord, a second very scalar cord within the umbilicus and a third, with axially elongate blade-like spines, at the point of articulation with the earlier whorl; whorl profile circular in cross section, modified by spiral sculpture; axial macrosculpture expressed as faint undulations on the base; base sometimes with fairly prominent spiral cords; umbilicus open, deep, exposing early whorls; growth form very low spired to biconcave in early juvenile becoming low spired in the adult; largest known specimen, the holotype, 3.44 mm in diameter, 2.40 mm high, with a .56 mm internal umbilical diameter, and an internal apertural diameter of 1.36 mm at slightly under 3 post-protoconch whorls.

Comparisons.- Lack of a turbinate growth form clearly separates Arene lis from the type species of Arene, A. cruentata (Muehlfeld). This same character also distinguishes A. lis from other common Arene of the Gulf province: A. variabilis (Dall) and A. gemma (Tuomey and Holmes). Arene venustula Aguayo and Rehder has only two rows of peripheral spines and A. vanhyningi Rehder lacks axial microsculpture. Species referable to the subgenus Marevalvata Olsson and Harbison are rather similar to A. lis but have a single umbilical cord while A. lis has three.

The species of Arene which most resemble A. lis are three

that have not previously been referred to Arene: Cyclostromella (sic) venezuelana Weisbord, 1962, Cyclostrema cubana Aguayo, 1948, and "Liotia" canimarensis Aguayo and Borro, 1946. Each is known only from its type lot and in each species, all known specimens are juvenile fossils.

In the original description of Cyclostromella venezuelana, Weisbord (1962, p. 137) noted that the holotype and only specimen might be a juvenile. Moore (1966, p. 480) confirmed this. The species is known only from the Pliocene of northern Venezuela.

The holotype of Cyclostromella venezuelana is congeneric with Arene lis. At a comparable growth stage, A. lis is almost three times as large. Elements of sculpture, growth form, and protoconch-teleoconch relationships are very similar or the same.

Cyclostrema cubana Aguayo is another species of this stock. The type specimen, from the Middle Oligocene of Cuba, is 1.5 mm in maximum diameter and young enough to preserve the biconcave growth form of the early juvenile. This species, which is not illustrated in umbilical view, expands less rapidly and has a longer biconcave stage than A. lis. It is known from a single specimen (Aguayo, 1948, p. 59). If illustrations of the type specimen of A. cubana are correct in detail, this species also resembles A. lis in that axial macrosculpture arises from every twelfth microvarix.

"Liotia" canimarensis Aguayo and Borro is somewhat more ornate than the other species but seems clearly congeneric. It is from the Upper Miocene of Cuba and was described from two specimens (Aguayo and Borro, 1946, p. 11). There are four peripheral spirals

and a scalar spiral at the base. At about 2.3 post protoconch whorls, the shell is only 2.05 mm in diameter and it thus seems much smaller than A. lis, though the size of this species is variable. The illustrated specimen of A. canimarensis appears to be about one whorl short of full growth. It is at the most spinose juvenile stage, just passing out of the biconvex stage.

Remarks.- From mudlump specimens it is possible to describe a complex sequence of ontogenetic changes in sculpture and growth form in Arene lis. These can be recognized in described species of microgastropods that have previously been assigned to other genera but are small, rare, and poorly known. Neither A. lis nor any of the species close to it can be meaningfully compared to the type specimen of Arene or other common Western Atlantic forms.

The extremely abundant axial microsculpture of A. lis and similar forms records hundreds of growth stops. Each microvarix is interpreted as a former apertural position that was abandoned and when growth was resumed, shell material was secreted within the former aperture. These, plus periodic major growth stops, represented by spinose and modular axial sculpture, suggest growth is slow in A. lis and its allies.

Nine of the fifteen mudlump specimens are sufficiently well preserved to permit measurement of diameter. These range from 1.24 to 3.44 mm with an average of 2.09 mm. Specimens with about 2.7 post-protoconch whorls range from 2.90 to 3.44 mm.

From the morphology and size range of mudlump A. lis, it

appears that the species grows discontinuously toward a variable maximum size reached at about three post-protoconch whorls. Only three of thirteen mudlump specimens closely approximate this apparent maximum number of whorls and it is not certain that a fully grown adult is known.

Arene venezuelana, A. cubana, and A. canimarensis are known from a total of four shells. They seem very similar to A. lis and, since less than one A. lis in four is more or less adult, it is not surprising that adults of these three little-known species have not been reported.

Arene lis and closely allied species seem to be a monophyletic group. In addition to morphologic similarity, they appear to share a pattern of discontinuous growth and growth in all species is presumably slow. They also share a population structure in which late juvenile and early adult individuals dominate.

Derivation of Name.- From the Latin lis, in the sense of conflict, in allusion to the conflicting growth form and sculpture or early juveniles and late adults.

Occurrence and Abundance.- SP 1-B, -8.25 to 8.38' (1), -351.8 to 352.0' (1), SP 5 (3); SP 94 (2); PAL 7 (8).

Holotype.- LSUDGMTC 7359.

Figured Specimens.- LSUDGMTC 7359-7361.

Order MESOGASTROPODA Thiele, 1925

1925. Mesogastropoda THIELE, Mollusca In Kuekenthal, W., Handb. Zool., v. 5, p. 74.

Diagnosis.- Prosobranchs with internal fertilization; dioecious or hermaphrodite; primitively with pectinibranch ctenidium; shell bearing; radula taeniglossate.

Superfamily RISSOACEA H. and A. Adams, 1854

1854. Rissoacea H. AND A. ADAMS, Gen. Rec. Moll., v. 1, p. 327.

Diagnosis.- Mesogastropods of small to microscopic size, generally high spired; variously sculptured; operculate; dioecious, herbivorous; gill normally with few filiments, simple; generally with a crystalline style in digestive system, a non-pelagic larval stage, attached egg masses, and a short life span; generally able to weave a mat, web, or thread from mucous secreted by pedal mucous glands, secretions used for support and in movement.

Family RISSOIDAE H. and A. Adams, 1854

1854. Rissoidae H. AND A. ADAMS, Gen. Rec. Moll., v. 1, p. 327.

Diagnosis.- Rissoacea of high spired growth form without an apophysis on the interior of the operculum; foot narrow and very glandular; with a metapodial tentacle; aperture circular to ovate, apertural margin thickened, without major development of anterior or posterior

sinuses; secretive tissue of posterior pedal mucous gland extending into head; generally with a free-swimming larvae.

Genus ALVINIA Monterosato, 1884

1884. Alvinia MONTEROSATO, Natural. Sicily, v. 3, p. 160.

1964. Alvinia Monterosato: COEN, Veliger, v. 6, p. 165.

Type Species.- By subsequent designation, Crosse 1885, Rissoa weinkauffi Monterosato.

Diagnosis.- Rissoids with spiral and axial sculpture; whorls slowly expanding; spire moderately elongate; protoconch and teleoconch clearly differentiated, generally separated by a small varix; size small, generally under 5 mm.

Alvinia auberiana Orbigny, 1841

Plate VI, Figures 1-2

1841. Rissoa auberiana ORBIGNY In Sagra, Ile d'Cuba, Moll., v. 1, p. 22, pl. 11, figs. 34-36.

1961. Alvania auberiana Orbigny: WARMKE AND ABBOTT, Caribbean Seashells, p. 58, pl. 10, fig. K.

Description.- Alvinia with spiral and axial macrosculpture equally developed, faint beads developed where spiral and axial ribs intersect; spire fairly high, whorl profile rounded, slightly inflated, suture impressed; with three prominent spiral ribs on periphery of spire;

eight spiral ribs on body whorl; microsculpture of faint spiral lines, about 23 on penultimate whorl; body whorl with 26 axial ribs which become faint and die out on the base; protoconch about 1.75 whorls, smooth; teleoconch at least 2.5 whorls, with all elements of ornamentation simultaneously introduced, sculpture faint on first .25 whorl; umbilicus chink-like; peristome thickened; aperture slightly elliptical; size at 2.5 teleoconch whorls, 1.26 mm in length, .86 mm in width, aperture approximately .46 mm in transverse diameter.

Remarks.- Orbigny's figure of this species is unusually good. Mudlump specimens seem slightly more inflated than those figured by Orbigny or Warmke and Abbott, but they are clearly conspecific.

Distribution.- West Indies.

Occurrence and Abundance.- SP 1-B, -350.9 to 351.1 (1); SP 6 (7).

Figured Specimen.- LSUDGMTC 7342.

Family RISSOINIDAE Stoliczka, 1868

1868. Rissoininae STOLICZKA, Mem. Geol. Survey India, Paleont. Indica, ser. 5, v. 2, p. 276.

Diagnosis.- Rissoacea of high spired growth form with an apophysis on the inner side of a horny operculum; aperture semilunate, with anterior and posterior sinuses, outer lip generally thickened; generally with complex reproductive system and secretive tissue of posterior pedal gland confined to the foot.

Genus ZEBINELLA Moerch, 1876

1876. Zebinella MOERCH, Malak. Blaet., v. 23, p. 47.

1964. Zebinella Moerch: COEN, Veliger, v. 6, p. 169.

Type Species.- By subsequent designation, Nevill 1885, Helix decussata Montagu.

Diagnosis.- Shell small, high spired, elongate, body whorl about half total length; nucleus elevated, 2-3 whorls, smooth; adult sculpture of axial riblets and fine spiral thread; aperture semilunate, lip patulate, somewhat thickened; with a strong posterior sinus above and a shallow siphonal canal below; size generally under 10 mm.

Zebinella decussata (Montagu), 1803

Plate VI, Figure 6

1803. Helix decussata MONTAGU, Test. Brit., p. 399.

1845. Rissoa albida C. B. ADAMS, Proc. Boston Soc. Nat. Hist., v. 2, p. 6.

1949. Rissoina (Zebinella) decussata (Montagu): DESJARDIN, Jour. Conchyliologie, v. 89, p. 200, pl. 9, fig. 11.

Description.- Zebinella of slender growth form, suture moderately impressed; with 25 to 30 axial ribs on body whorl; adult 6-8 mm in length.

Remarks.- Desjardin (1949) gave a more detailed synonymy.

Distribution.- North Carolina to the Antilles in shallow water.

Occurrence and Abundance.- PAL 7 (1, broken).

Figured Specimen.- LSUDGMTC 7372.

Genus PHOSINELLA Moerch, 1876

1876. Phosinella MOERCH, Malak. Bl., v. 23, p. 51.

1964. Phosinella Moerch: COEN, Veliger, v. 6, p. 169.

Type Species.- By subsequent designation, Nevill 1885, Rissoa pulchra C. B. Adams (= Rissoina cancellata Philippi).

Diagnosis.- Shell small, high spired, slender; nucleus of 2-3 whorls; very ornate in adult, strongly reticulate spiral and axial ribs, often beaded; posterior siphonal channel shallow, anterior broad and deep; siphonal fasciole low and broad.

Remarks.- Coen (1964) makes Phosinella the type of the Phosinellinae Coen. The subfamily is characterized by cancellate sculpture.

Phosinella cancellata (Philippi), 1847

Plate VI, Figure 8

1847. Rissoina cancellata PHILIPPI, Malak. Zeitschr., 1847, p. 127.

1850. Rissoa pulchra C. B. ADAMS, Contrib. Conch., no. 7, p. 114.

1949. Rissoina (Phosinella) cancellata Philippi: DESJARDIN, Jour. Conchyliologie, v. 89, p. 204, pl. 10, fig. 3.

Description.- Phosinella with 16 to 18 axial and 4 to 5 spiral ribs; spiral ribs more numerous on base; spiral and axial ribs equally prominent; basal notch well developed; maximum length about 8 mm.

Remarks.- Desjardin (1949) gives a more detailed synonymy.

Distribution.- Southeastern Florida to the Antilles, generally believed to live only in shallow water.

Occurrence and Abundance.- PAL 7 (5, All juvenile); SP 1-B, -348.8 to 349.0 (1); -350.9 to 351.1 (1); SP 5 (1).

Figured Specimen.- LSUDGMTC 7373.

Genus ZEBINA H. and A. Adams, 1854

1854. Zebina H. AND A. ADAMS, Gen. Rec. Moll., v. 1, p. 328.

1964. Zebina H. and A. Adams: COEN, Veliger, v. 6, p. 169.

Type Species.- By subsequent designation, Nevill 1855, Rissoina coronata (Recluz, ms.) Mohrenstern.

Diagnosis.- Rissoinids with a more or less massive shell in the late adult; generally rather rapidly expanding, with a moderately high spire, stubby; without spiral sculpture; with subdued axial sculpture or smooth; with or without a dentate outer lip.

Remarks.- Coen (1964) makes Zebina the type of the Zebininae Coen, characterized by reduction or lack of axial sculpture and the absence of spiral sculpture.

ZEBINA (IOPSIS) Gabb, 1873

1873. Iopsis GABB, Proc. Acad. Nat. Sci. Philadelphia, 1872, p. 272.

1928. Cibdezebina WOODRING, Carnegie Inst. Washington Pub. 385, v. 2, p. 369.

1964. Iopsis Gabb: COEN, Veliger, v. 6, p. 169.

Type Species.- By monotypy, Iopsis fusiformis Gabb (= Rissoina browniana Orbigny), also the type of Cibdezebina Woodring.

Diagnosis.- Zebina of small size; smooth; massive; nucleus clearly demarcated, elevated, about 3 whorls; outer lip thickened; sometimes with denticle on inner side of outer lip; siphonal canal weakly developed.

Zebina (Iopsis) browniana (Orbigny), 1841

Plate VI, Figure 7

1841. Rissoina browniana ORBIGNY, In Sagra Hist. Nat. Ile Cuba, Moll., v. 2, p. 28.

1850. Rissoa laevigata C. B. ADAMS, Contrib. Conch., p.114.

1873. Iopsis fusiformis GABB, Proc. Acad. Nat. Sci. Philadelphia, p. 272.

1873. Eulima crassilabris GABB, Tr. Amer. Phil. Soc., v. 15, p. 227.

1949. Rissoina (Zebina) browniana Orbigny: DESJARDIN, Jour. Conchy., v. 89, p. 205, pl. 10, fig. 4.

1953. Rissoina (Cibdezebina) browniana Orbigny: OLSSON AND HARBISON, Mon. Acad. Nat. Sci. Philadelphia, no. 8, p. 326.

Description.- Zebina (Iopsis) with a short, flat-sided spire; lower margin of penultimate whorl overhanging body whorl; outer lip quite patulate in front; generally with a small posterior tooth on outer lip, with or without a basal tooth.

Remarks.- Desjardin (1949) and Olsson and Harbison (1953) give fuller synonymies.

Distribution.- Miocene to Recent throughout the North Carolina-Antillean region.

Occurrence and Abundance.- PAL 7 (1).

Figured Specimen.- LSUDGMTC 7374.

Rissoacea Incertae Sedis

(Superfamily Unknown)

Diagnosis.- Mesogastropods of small to microscopic size; generally subturbinate to discoidal; herbivorous; operculate; variously sculptured; dioecious; anatomy where known shows reduction in organ systems associated with small size; occasionally with crystalline style; sometimes with eggs attached, without pelagic larval stage; generally able to swim; life span where known approximately one year or less.

Remarks.- Fretter and Graham (1962) review the anatomy of rissoid-like genera and recognize two basic stocks: Rissoacea and Rissoacea Incertae Sedis. Taylor and Sohl (1964) place all these forms in Rissoacea, and with two families added by Moore (1962), the Rissoacea become the second most generically diverse gastropod superfamily. Subdivision by Fretter and Graham seems valid.

Ability to mold pedal mucous into a locomotive aid is a basic adaptation of the Rissoacea. In some of the Rissoacea Incertae Sedis, such as Skeneopsis, use of mucous is developed even beyond the stage of the Rissoacea s.s. (Fretter and Graham, 1962). Use of mucous has not been observed in taxa discussed below.

The Rissoacea Incertae Sedis are a prime focus of dissertation research.

Family PARVITURBOIDIDAE Corgan, new family

Diagnosis.- Mesogastropods of small to microscopic size, usually under 2.5 mm in diameter; discoidal to turbinate growth form; orthostrophic; with protoconch and teleoconch sharply demarcated; protoconch smooth, 1.5 to 2.5 or more whorls; teleoconch generally 3 whorls or less, ornate throughout or with sculpture becoming obsolescent in the adult; spiral sculpture of numerous prominent ridges which may be minutely beaded; with or without axial sculpture of minute to microscopic ribs or threads which, when present, are usually decussate; sometimes with broad axial ribs on body whorl; spiral sculpture and axial microsculpture well defined and simultaneously introduced at the beginning of the teleoconch; umbilicate, umbilicus variable, generally small and deep; peristome continuous; aperture simple.

Content.- Parviturboides (Parviturboides) Pilsbry and McGinty, 1950, P. (Denseturboides) Corgan, new subgenus, P. (Polylixia) Corgan, new subgenus, Aorotrema Pilsbry, 1953, and Quadrilixia Corgan, new genus.

Comparisons.- Parviturboidids lack the heavy shell and coarse sculpture of most adult liotids and liotids are archaeogastropods. Though parviturboidids have long been considered part of the Vitrinellidae, sculpture and gross form are quite distinctive and no true vitrinellid has the sharply differentiated protoconch and teleoconch which is characteristic of the parviturbidids. Some of the Rissoidae resemble parviturbidids in the protoconch-teleoconch relationships, but parviturbidids lack the rissoid aperture.

Two of the parviturbidid genera, Aorotrema and Quadrilixia, closely resemble juvenile Turbinidae, a family of archaeogastropods. Evidence is presented in the discussion of Aorotrema which strongly suggests that these genera must be regarded as microscopic in the adult.

Protoconch-teleoconch relationships in Aorotrema and Quadrilixia are like those of Parviturboides, and, in a broad interpretation, Aorotrema may also be considered similar to Parviturboides in all elements of sculpture.

In details of sculpture, growth form, and rate of size increase, Aorotrema and Quadrilixia form a group quite distinct from Parviturboides s.s. and its various subgenera.

Placement.- Moore (1962) described the living animal of Parviturboides interruptus (C. B. Adams) and the pattern of ciliation is strong evidence of an affinity with the rissoid stock.

Remarks.- The clear separation of protoconch and teleoconch suggests that the Parviturboididae is characterized by a pelagic larval stage. Pilsbry and McGinty (1945b) note that the type species of Parviturboides has a bifid foot. Moore (1962) gives an outline drawn of the body of P. interruptus. The pattern of ciliation is comparable to the Rissoacea. A planktonic larva, bifid foot, and rissoacean ciliation are probably characters of the Parviturboididae but the animal is known in too few species to permit generalization.

Range and Trends.- The family first appeared in the Miocene of the Gulf of Mexico province and is now present in both the Atlantic and Pacific faunas of North America. Parviturboides s.l. and Aorotrema-Quadrilixia are distinct lineages from their earliest appearance.

Genus PARVITURBOIDES Pilsbry and McGinty, 1950

1950. Parviturboides PILSBRY AND McGINTY, Nautilus, v. 63, p. 86.

Type Species.- By original designation, Cyclostrema sanibelensis Pilsbry (error for C. sanibelense Pilsbry, 1939 = C. zacalles Mazyck, 1913 = Vitrinella interruptum C. B. Adams, 1850).

Diagnosis.- Parviturboidids of subturbinate to depressed growth form, generally thin shelled; protoconch 1.5 to 2.5 or more whorls; teleoconch 4 whorls or less; spiral sculpture of a few to many prominent spiral ridges; axial microsculpture of decussate axial lines; sometimes with axial macrosculpture on body whorl; umbilicus narrow, generally bounded by a spiral cord; inner lip variously thickened; operculum thin, multispiral.

Content.- The nominal content of Parviturboides is given in Table 13 and a register of type and reference specimens examined in the course of this study appears in Appendix 4.

Three subgenera of Parviturboides are here recognized. Diagnoses are given below. Content of subgenera is listed in Table 13 and temporal distribution is shown in Figure 4.

Table 13

NOMINAL CONTENT OF PARVITURBOIDES

Species	Placement
Parviturboides avitus Pilsbry, 1953	
Fossarus (Gottoina) bella Dall, 1889[1]	*P. (Denseturboides)*
Parviturbo decussatus clausus Pilsbry and Olsson, 1945	
Fossarus comptus Woodring, 1928	*P. (Denseturboides)* n. subgen.
Parviturbo copiosus Pilsbry and Olsson, 1945	*P. (Polylixia)* n. subgen.
? *Vitrinella decussata* Carpenter, 1857	
Parviturbo germanus Pilsbry and Olsson, 1945	*P. (Polylixia)* n. subgen.
Vitrinella interrupta C. B. Adams, 1850	
Liotia (Arene ?) milium Dall, 1892[1]	*P. (Denseturboides)* n. subgen.
Vitrinella monile Carpenter, 1857	*P. (Polylixia)* n. subgen.
Vitrinella monilifera Carpenter, 1857	*P. (Polylixia)* n. subgen.
Cyclostrema sanibelense Pilsbry, 1939	
Delphinula tuberculosa Orbigny, 1841	*P. (Denseturboides)* n. subgen.
Cyclostrema zacalles Mazyck, 1913	

[1]Not previously referred to *Parviturboides*.

EXPLANATION OF FIGURE

1. Numbers refer to position in the alphabetic list of nominal species given in Table 13.
2. Since most Parviturboides are known from small hypodigms, figures plotted are maxima for species rather than averages. An exception is made in the case of species 8, which is plotted twice. For explanation see the description of Parviturboides interruptus (C. B. Adams).
3. Rib counts generally reflect direct observation but size is taken from the literature since facilities for measurement were not available in the U.S. National Museum or the Academy of Natural Sciences of Philadelphia.
4. No size data are available for species 2 or 13.
5. Species 12 and 14 are considered synonyms of species 8 and were not plotted.

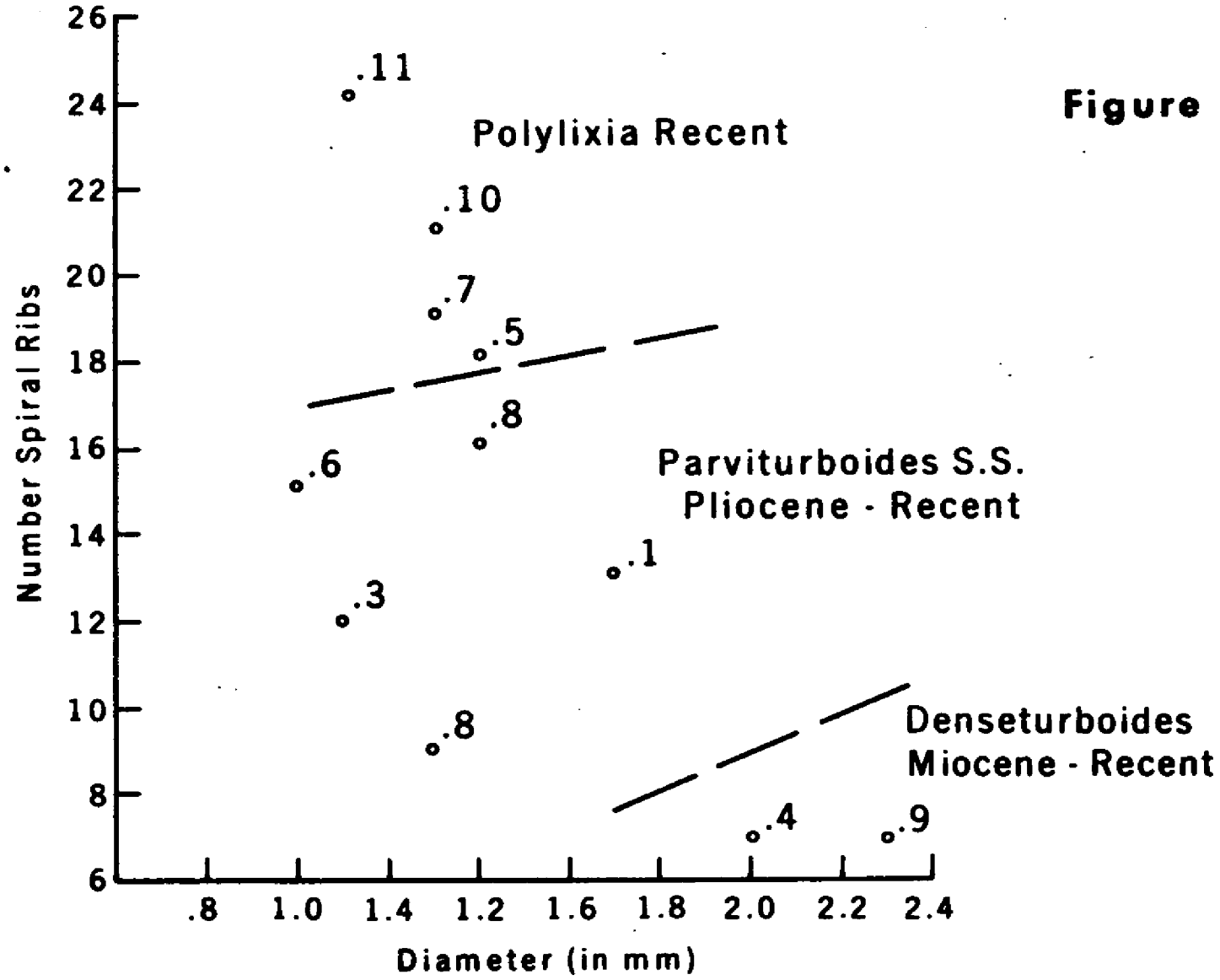


Figure 4

SCULPTURE AND SIZE IN PARVITURBOIDIDS

PARVITURBOIDES (DENSETURBOIDES) Corgan, new subgenus

Type Species.- Here designated, Liotia (Arene) milium Dall.

Diagnosis.- Parviturboides with a moderately elevated, though subturbinate spire; height equal to or greater than diameter; protoconch 1.5 or more whorls; teleoconch generally 3 or more whorls; suture distinct, sometimes impressed; spiral sculpture relatively coarse, with few ribs; shell relatively thick.

Comparisons.- Distinguishing characters are a higher spire, coarser sculpture, thicker shell, greater number of teleoconch whorls, and greater diameter than other Parviturboides.

Derivation of Name.- The prefix is from the Latin densus, thick. Turboides is a diminutive from the Latin turbo, that which whirls.

PARVITURBOIDES (PARVITURBOIDES) Pilsbry and McGinty, 1950

Diagnosis.- Parviturboides of subturbinate growth form; broader than high; with many spiral ribs of low amplitude; shell relatively thin; protoconch generally 2 to 2.7 whorls; teleoconch 2 whorls or less.

PARVITURBOIDES (POLYLIXIA) Corgan, new subgenus

Type Species.- Here designated, Parviturbo germanus Pilsbry and Olsson.

Diagnosis.- Parviturboides of subturbinate to depressed growth form; broader than high with 1.5 to 2 or more protoconch volutions; spiral

ridges very numerous, low, equal or subequal; axial lines minute, very numerous; aperture ovate; inner lip sometimes thickened.

Comparisons.- Distinguishing characters are more spiral ribs, a more depressed growth form, and, because of the greater number of less elevated ribs, a less angular whorl profile.

Derivation of Name.- From Greek roots for many ribs.

Ecology of Parviturboides.- Pilsbry and McGinty (1945b, p. 58) record Parviturboides (Parviturboides) interruptus as epifauna on sponges from two localities and Mazyck (1913, p. 18) recorded it in sand sifted from the interior of a sponge. Since one of Mazyck's specimens had the radula in place, it was alive at the time of collection.

Pilsbry and McGinty (1945b) also record P. interruptus as epifauna on the flat-spined bivalve Atrina. Only Moore (1964a) has observed P. interruptus in life. Specimens hide under objects or in crevices during daylight hours. Moore's text suggests they are part of the general vagrant benthos, not epifauna on other invertebrates.

In the Pacific, all ecologic information comes from Carpenter (1857). He collected Parviturboides (Polylixia) decussatus from the spinose and rough-surfaced bivalves. Both Spondylus and Chama, a similar bivalve, yielded Parviturboides (Polylixia) monile.

Warmke and Almodovar (1963) have recorded Parviturboides, species unidentified, from algae in Puerto Rico; however, it is not certain that their taxon is a Parviturboides in the sense of the present report. Parviturboides is a very minor element in their fauna.

All available data suggest that species of Parviturboides, at least "advanced" Parviturboides, characteristically occur on rough, irregular surfaces that provide many hiding places for a very small gastropod. In its most frequent mode of occurrence, Parviturboides is a cleaning organism. It lives on, or in, another animal. The host species, willing or not, provides a residence, strong water circulation, and access to a supply of vegetal food. To the host species, this food supply is deleterious, an organic fouling. Parviturboides probably aids its host by removing or reducing this fouling.

Range and Trends.- A simple plot of diameter against number of spiral ribs is shown in Figure 2. The figure is self-explanatory and limits of data are indicated. Plots of height and diameter and height and number of ribs show the same pattern.

The stratigraphic distribution of morphologic groups in Parviturboides can be interpreted in light of the ecology of modern forms. A low spire and small size should be advantageous to an organism that hides in small spaces. In addition, animals with many low ribs have a more regular whorl profile than those with a few high ribs. They might be better able to pass through small spaces.

Parviturboides interruptus (C. B. Adams), 1850

Plate VIII, Figures 2-3, 6

1850. Vitrinella interrupta C. B. ADAMS, Monograph Vitrinella, p. 6.

1913. Cyclostrema zacalles MAZYCK, Contrib. Charleston Mus., v. 2, p. 18.

1939. Cyclostrema sanibelense PILSBRY, Nautilus, v. 53, p. 53, pl. 8, fig. 3.

1940. Cyclostrema sanibelense Pilsbry: PERRY, Mar. Shells southwest coast Florida, p. 102, pl. 22, figs. 141a-b.

1945. Parviturbo zacalles (Mazyck): PILSBRY AND McGINTY, Nautilus, v. 59, p. 57, pl. 6, figs. 2, 2a, 5.

1945. "Cyclostrema" interruptum sanibelense Pilsbry: PILSBRY AND McGINTY, Nautilus, v. 59, p. 58, pl. 6, fig. 9.

1946. Cyclostrema interruptum (C. B. Adams): PILSBRY, Not. Nat. Acad. Nat. Sci., Philadelphia, no. 162, p. 5, figs. 4-5.

1950. Parviturboides interruptus (C. B. Adams): PILSBRY AND McGINTY, Nautilus, v. 63, p. 86.

1950. Parviturboides interruptus (C. B. Adams): CLENCH AND TURNER, Occ. Pap. Moll., Mus. Compar. Zool., Harvard Univ., v. 1, p. 294, pl. 35, figs. 4-5.

1958. Parviturboides interruptus (C. B. Adams): OLSSON AND McGINTY, Bull. Amer. Paleont., no. 177, p. 12.

1962. Parviturboides interruptus (C. B. Adams): MOORE, Bull. Mar. Sci. Gulf and Caribbean, v. 12, p. 697, fig. 1-b.

Description.- Parviturboides with 12-16 spiral ribs; 7-9 spirals are generally far more prominent with one forming an elevated cord around the umbilicus; umbilicus deep, small, without internal spiral ornamentation; inner lip thickened, slightly reflected in large specimens; axial riblets very numerous, developed only in grooves between spiral ribs, subequally developed in adjacent grooves; protoconch 2-1/3 to

2-2/3 volutions, almost always .44 mm in maximum diameter; teleoconch uniformly about 1-1/2 volutions; adult diameter varies from 1.1 to 1.4 mm, height 85-90% of width.

Remarks.- Moore (1964a) describes the living animal in detail and records a planktonic larva. Basic entries in the synonymy of P. interruptus follow comments and suggestions by Pilsbry and McGinty (1950, p. 86) and were evaluated in light of type material (Appendix 4).

Prior workers have not noted that the type specimen of Cyclostrema sanibelense Pilsbry is an aberrant specimen. It is apparently representative of a fairly widespread genotype or race that occurs in western Florida. Subsutural costae are strongly suppressed and the apical portion of the peristome is deflected downward. Three paratypes, ANSP 18119a, also show this character but a second lot of seven paratypes, ANSP 174896, are normal. Suppression of sculpture and deflection of the peristome appear to be population characters without taxonomic significance, as the synonymy given above indicates.

Geographic Distribution.- South Carolina to Panama.

Bathymetric Distribution.- Four to 50 fathoms. Discussion by Moore (1964a, unpublished doctoral dissertation) implies the species occurs in the intertidal zone.

Occurrence and Abundance.- SP 1-B, -350.9 to 351.1 (3), -455.75 to 456.75 (3); SP 5 (2); SP 6 (56); SP 94 (6).

Figured Specimen.- LSUDGMTC 7381.

Genus QUADRILIXIA Corgan, new genus

Type Species.- Here designated, Aorotrema gardnerae Pilsbry, 1953.

Diagnosis.- Parviturboidids of turbinate growth form, height and width subequal, height slightly greater; build sturdy, shell moderately thick; protoconch relatively large, about 1.5 volutions; teleoconch 2 or more whorls; spiral sculpture of prominent keels, an apical keel, two medial keels, and an umbilical keel; without spiral microsculpture; with axial sculpture of widely spaced impressed furrows which cross keels; with a thickened inner lip.

Content.- Monotypic.

Comparisons.- Quadrilixia is very similar to Aorotrema Pilsbry. Prime differences are the absence of spiral microsculpture in Quadrilixia and presence of axial furrows and a thickened inner lip.

Remarks.- Quadrilixia is diagnosed primarily to clarify the scope and content of Aorotrema. Diagnosis is based on the holotype and only known specimen of Aorotrema gardnerae, No. 19550, in the collections of the Academy of Natural Sciences of Philadelphia.

Derivation of Name.- From Greek roots for four ribs.

Occurrence.- Quadrilixia gardnerae (Pilsbry) is known only from the Upper Miocene of Natural Well, Duplin County, North Carolina (Pilsbry, 1953, p. 424).

Genus AOROTREMA Pilsbry, 1953

1942. Aorotrema SCHWENGEL AND McGINTY, Nautilus, v. 56, p. 17. (Nomen nudum).

1945. Aorotrema (Schwengel and McGinty) PILSBRY AND McGINTY, Nautilus, vo. 59, p. 11. (Nomen nudum).

1952. Aorotrema (Schwengel and McGinty) PILSBRY AND OLSSON, Proc. Acad. Nat. Sci., Philadelphia, v. 104, p. 82. (Nomen nudum).

1953. Aorotrema (Schwengel and McGinty) PILSBRY, Acad. Nat. Sci., Philadelphia, mon. 8, p. 423.

Type Species.- By original designation, Cyclostrema pontogenes Schwengel and McGinty, 1942.

Diagnosis.- Parviturboididae of turbinate growth form, width and height about equal, build sturdy, shell moderately thick; protoconch small, orthostrophic, 2 whorls or less, simple, sharply separated from teleoconch; teleoconch generally 2 or more whorls; all elements of ornamentation abruptly introduced, perfect specimens show a small varix between protoconch and teleoconch; teleoconch with prominent spiral keels, generally 3 keels, an apical keel which forms a strong shoulder, a peripheral keel, and an umbilical keel; apical surface of whorl flat, concave from shoulder to peripheral keel, from periphery to umbilical keel generally more or less convex; densely covered with coarse spiral threads, threads generally wider than the interspaces; dense axial sculpture of fine threads, intersection with spiral threads produces a beaded surface; umbilicus prominent, inclined to the axis of growth;

peristome continuous, body whorl sometimes loosely attached, attachment variable within species; aperture modified by spiral keels; animal unknown; size, under 2.5 mm.

Publication.- In 1942, Schwengel and McGinty (p. 17) described Aorotrema by indication, without a word statement of characters and without comparison with other genera. Only one species, Cyclostrema (Aorotrema) pontogenes Schwengel and McGinty was unequivocally referred to Aorotrema. It may thus be inferred that Aorotrema was conceived of as a monotypic unit, though the comparison with Cyclostrema cistronium Dall might suggest, to some interpreters, that both species were referred to Aorotrema.

Pilsbry and McGinty (1945, p. 11) were the next to treat Aorotrema. They provide a clear statement of characters and a comparison with a juvenile Turbo. Two described species are referred to Aorotrema and a third is added. Their statement that Aorotrema is "Subgenus for Cyclostrema pontogenes S & M" cannot be interpreted as the fixation of a type under the International Code of Zoological Nomenclature. They treat Aorotrema as a genus, not a subgenus.

Their statement appears to be an interpretation of the intent of Schwengel and McGinty to establish a monotypic subgenus based on Cyclostrema pontogenes. Pilsbry and McGinty did not designate a type and Aorotrema remained a nude name.

Requisites for authorship under the International Code of Zoological Nomenclature were first fulfilled by Pilsbry in 1953 (p. 423).

Content.- The nominal content of Aorotrema is listed in Table 14 and a register of type and reference specimens examined in the course of this study is given in Appendix 4.

Aorotrema erraticum Pilsbry and McGinty, 1945, differs from other nominal species in several important respects: the body whorl is detached, there is no fine spiral sculpture and no axial sculpture. It is known only from the holotype. Moore (1964a) considers it the pathologic juvenile of a megascopic Turbo. This interpretation, based on Moore's examination of the holotype, seems proper. The species is here excluded from Aorotrema and is not covered by the diagnosis given above.

Actually, pathologic conditions similar to the detached peristome of Aorotrema erraticum occur in Aorotrema. One specimen of A. cistronium in the U.S. National Museum, No. 95083, has the peristome completely detached and strongly resembles A. erraticum in this respect.

Remaining species of Aorotrema appear congeneric. The type species, A. pontogenes (Schwengel and McGinty), has less prominent axial sculpture than other species of the genus and also lacks sculpture within the umbilicus. It is pathologic. The only known specimen suffered a bad break. Secretion of the last half of the body whorl was abnormal.

Range and Trends.- In the modern fauna, Aorotrema is known from the Pacific Ocean near Port Parker, Costa Rica, and from North Carolina to western Florida in the Atlantic. The genus first appeared in the

Table 14

NOMINAL CONTENT OF AOROTREMA

Species	Placement
Cyclostrema cistronium Dall, 1889	
Aorotrema erraticum Pilsbry and McGinty, 1945	Turbo
Aorotrema gardnerae Pilsbry, 1953	Quadrilixia n. gen.
Cyclostremiscus humboldti Hertlein and Strong, 1951	
Cyclostrema pontogenes Schwengel and McGinty, 1942	

Pliocene of the Atlantic Coast and the Pliocene-Recent species is the largest known. Too few species are known to permit discrimination of trends. Known distribution strongly suggests the genus was well established in the faunas of both coasts during the Neogene.

Aorotrema nicholsi Corgan, n. sp.

Plate VI, Figures 3-5

Description.- Aorotrema with keels on body whorl thinning markedly toward the periphery, sometimes becoming frilled and undulose; all keels sharply defined; spiral riblets and transverse striae continuous over keels; spiral and axial ornamentation well developed within umbilicus. At 3-1/2 volutions, the holotype measures .93 mm in height and 1.21 mm in width. A paratype measures 1.02 mm in height and 1.30 mm in width.

Comparisons.- Aorotrema nicholsi is most comparable to A. cistronium (Dall), 1889 (= Cyclostrema cistronium Dall), but this long-described species is virtually twice as large. It also has a significantly smaller area of peristomal attachment. Lack of undulation in the keels of A. cistronium is a further, though minor, distinction between these two taxa.

Differences between Aorotrema nicholsi and A. cistronium appear comparable to those between A. cistronium and the Pacific species of Aorotrema which Hertlein and Strong (1951, p. 110-111, pl. 10, fig. 1) described as Cyclostremiscus humboldti. On this basis, A. nicholsi is here considered a distinct species.

Derivation of Name.- In honor of Lewis G. Nichols, Assistant Curator, Department of Geology Museum, Louisiana State University.

Occurrence and Abundance.- SP 94 (1); SP 1-A, -456.55 to 456.75' (1), SP 6 (1).

Holotype.- LSUDGMTC 7377.

Figured Specimen.- LSUDGMTC 7377.

Family CAECIDAE H. and A. Adams, 1854

1854. Caecidae H. AND A. ADAMS, Gen. Rec. Moll., v. 1, p. 355.

Diagnosis.- Mesogastropods of minute to small size, coiled in the earliest juvenile becoming uncoiled in the later juvenile; adult uncoiled, generally truncated posteriorly.

Remarks.- Perhaps Gray introduced the term Caecidae before the brothers Adams. He is usually credited with authorship. When a date is cited, it is 1847 and Gray (1847) does not contain the term Caecidae.

Genus ELEPHANTANELLUM Bartsch, 1920

1920. Elephantanellum BARTSCH, Jour. Washington Acad. Sci., v. 10, p. 567.

Type Species.- By original designation, Caecum hexagonus Carpenter.

Diagnosis.- Caecids with shell posteriorly truncated in adult; sculpture of strong longitudinal ribs and concentric rings.

Elephantanellum imbricatum (Carpenter), 1859

Plate X, Figure 8

1859. Caecum imbricatum CARPENTER, Proc. Zool. Soc. London, 1858, p. 422.

Description.- Elephantanellum with 12 to 14 longitudinal ribs and

square axial annulae; cross-section polygonal; apical plug with a strong but narrow protrusion on the convex side; size, about 2 to 4 mm.

Remarks.- Identification of Carpenter's unillustrated species is discussed by Olsson and Harbison (1953, p. 319). They also provide a synonymy. Mudlump specimens differ a bit from many other populations of this variable species. The longitudinal ribs number 14 in all larger specimens and the transverse annulae are very much suppressed.

Distribution.- Florida to the Antilles. Bathymetric distribution unknown.

Occurrence and Abundance.- SP 6 (14).

Figured Specimen.- LSUDGMTC 7340.

Genus MICRANELLUM Bartsch, 1920

1920. Micranellum BARTSCH, Jour. Washington Acad. Sci., v. 10, p. 568.

Type Species.- By original designation, Caecum crebricinctum Carpenter.

Diagnosis.- Caecids with shell posteriorly truncated in adult; sculpture of strong transverse annulae, without longitudinal sculpture.

Micranellum regulare (Carpenter), 1859

Plate X, Figure 9

1859. Caecum regulare CARPENTER, Proc. Zool. Soc. London, 1858, v. 26, p. 428.

Description.- Micranellum with inflated, elevated annulae, annulae smaller than interspaces, about 25 annulae in an average adult; ribs generally uniform throughout late teleoconch, sometimes slightly larger near aperture or slightly smaller in region of maximum curvature; apical plug terminates in a mucro on the convex side; size, variable, generally about 2 mm in length with width 40 to 60% of length.

Remarks.- The largest mudlump specimen is 1.90 mm with a diameter of .98 mm.

Weisbord (1962, p. 162) gives a synonymy. Micranellum regulare is a fairly simple species. In growth form and sculpture it very strongly resembles a half dozen other nominal species of Micranellum from the Western Atlantic. Of these, only M. pulchellum (Stimpson), 1851, is a senior name. Cursory examination of U.S. National Museum and Academy of Natural Sciences of Philadelphia collections suggests that Stimpson's species is consistently wider and the annulae are coarser.

Distribution.- Miocene to Pleistocene, southern United States and northwestern South America. Recent, Florida to Brazil in shallow water.

Occurrence and Abundance.- SP 6 (49).

Figured Specimen.- LSUDGMTC 7341.

Family VITRINELLIDAE Bush, 1897

1897. Vitrinellidae BUSH, Trans. Connecticut Acad. Arts Sci., v. 10 p. 122.

1962. Circulidae FRETTER AND GRAHAM, British Prosobranch Gastropods, p. 642

In part, Adeorbidae, Tornidae, Delphinulidae, Cyclostrematidae, and Skeneidae of authors.

Diagnosis.- Mesogastropods of minute to microscopic, discoidal to naticoid, globular, or subturbinate; orthostrophic or heterostrophic; generally fairly thin shelled; usually hyaline, colorless, and transparent in living specimens; terminal portion of protoconch and teleoconch not clearly differentiated, sometimes indicated by a weak varix or weakly suggested by introduction of ornamentation in ornate forms; protoconch, where distinguishable, generally 2 whorls or less, teleoconch generally 4 whorls or less; sculpture, if present, generally dominated by spiral elements; umbilicate, umbilicus usually open, aperture simple, inclined; parietal callus, if present, generally thin; operculum, where known, rounded and multispiral.

Juvenile Coiling.- Both orthostrophic and heterostrophic forms are here included in the Vitrinellidae. This is a total departure from conventional practice. Two mudlump species have heterostrophic protoconchs. One, Vitrinella meta Corgan, bears a very strong resemblance to Vitrinella helicoidea C. B. Adams, the type species of Vitrinella. Possibly V. helicoidea is heterostrophic, but it has been described

and illustrated many times by skilled malacologists. Heterostrophy would, presumably, have been noted.

The taxonomic significance of differences in juvenile coiling is a matter of long-standing dispute. In current usage, the families Pyramidellidae, Epitoniidae, Janthinidae, Eulimidae, and Aclididae contain both orthostrophic and heterostrophic forms (Fretter and Graham, 1962, p. 640). Juvenile coiling in pyramidellids is discussed in detail later in the text. In other groups, orthostrophy is characteristic and in some heterostrophy is very doubtful. A family is generally either heterostrophic or orthostrophic, but Pruvot-Fol (1959) has shown that an occasional species has both orthostrophic and heterostrophic individuals.

Heterostrophy occurs only in individuals with pelagic larva and not all pelagic larval shells are heterostrophic. Within the Vitrinellidae as here constituted, heterostrophy and orthostrophy probably reflect differences in larval ecology or in larval growth form. These do not have greater significance than differences in the growth form or ecology of adults. Thus both orthostrophic and heterostrophic forms are included in the same family.

Quite recently, Moore (1964a) discovered that the "vitrinellid" genus Cyclostremella Bush has a heterostrophic protoconch. It was made the type of a new family. The original diagnosis of the Cyclostremellidae (Moore, 1966, p. 481) notes the presence of a labial sinus, dorsal canal, and chitinous operculum. As Moore conceived it, the Cyclostremellidae is clearly a valid family and contains a single

genus, Cyclostremella Bush, 1897. Heterostrophic "vitrinellids" that do not resemble Cyclostremella in all or most fundamental characters should not be referred to the Cyclostremellidae.

Remarks.- Historically, there has been much confusion as to the differences, if any, between the families Vitrinellidae, Cyclostrematidae, and Tornidae (= Adeoribidae). Iredale (1911; 1915b) discussed some of the problems which derive from varying designations of a type for Adeorbis and confirmed that Adeorbis Wood, 1842, and Tornus Turton and Kingston, 1830, are objective synonyms.

The family Cyclostrematidae is founded on Cyclostrema Marryatt, 1818, and the proper identity of C. cancellata Marryatt, 1818, the type species of Cyclostrema, was long unknown. Abbott (1950) shows that a Cyclostrema is a genus of small content referable to the family Liotiidae. It is characterized by small size, a discoidal shape, a thick shell, and coarse ornamentation. The shell does not bear a strong resemblance to any described vitrinellid and the anatomy of Cyclostrema bushi, described by White (1942), is very different from that of the Circulus dissected by Fretter (1956).

Differences between the Vitrinellidae and Tornidae are far less apparent than those between the Vitrinellidae and the Liotiidae. While most vitrinellids bear no close resemblance to Tornus, it is difficult to separate Circulus from Tornus on conchological grounds.

Taylor and Sohl (1962, p. 9, 14) consider the Tornidae and Vitrinellidae inseparable and retain the name Vitrinellidae on grounds of more frequent usage. In an opposing view, Fretter and Graham

(1962, p. 642) consider Circulus so distinct from known genera that they make it the type of the family Circulidae.

On conchological characters alone, both Circulus and Tornus are very near to Lower Paleozoic taxa such as the Ordovician Helicotoma recently illustrated by Yochelson (1966, p. 749) and the Jurassic Discophelix discussed by Fischer (1964). Clearly, modern systematics prohibits an emphasizing of apparent similarities and a lumping of all four taxa.

If soft anatomy is considered, it is easy to catalogue major differences between the type species of Tornus, dissected by Woodward (1899), and the type species of Circulus, dissected by Fretter (1956). Circulus has a penis, Tornus does not. Placement and structure of the gill are markedly different. Circulus has a circular, multispiral operculum and Tornus has an oval, paucispiral operculum. There are many other significant differences.

Contrasts in the shape and structure of the operculum correlate with a pronounced distinction in apertural form. The type species of Circulus has a circular aperture while the aperture of the type species of Tornus is quadrate.

Differences in apertural characteristics are the only significant conchological contrasts between these two taxa and would, ordinarily, be regarded as a basis for separation on the specific or subgeneric level.

Failure to recognize this conchological character as a basis for familial separation must lead to a questioning of the generic distinction of Circulus from Tornus. Since these taxa differ so

profoundly in soft anatomy, it seems best to assign greater-than-normal weight to an admittedly small conchological difference and refer them to distinct families.

It should, once again, be emphasized that Circulus is the only genus of the conventional Vitrinellidae that bears a notable conchological resemblance to Tornus, and that these genera differ in opercular character. Extreme anatomical distinction suggests that similarities in the shell are due to a strong evolutionary parallelism. Both genera are referable to the Rissoacea Incertae Sedis.

Range and Trends.- The Vitrinellidae range from Upper Cretaceous to Recent, occur on all continents, and have at least 500 nominal species. Discrimination of phyletic trends would require a complete revision of all major genera.

Genus VITRINELLA C. B. Adams, 1850

1850. Vitrinella C. B. ADAMS, Monogr. Vitrinella, p. 3.

1855. Not Vitrinella GRAY, Cat. Pulmonates, British Museum, v. 1, p. 52.

Type Species.- By subsequent designation, Bush 1897, Vitrinella helicoidea C. B. Adams.

Diagnosis.- Vitrinellids of small to medium size; protoconch either orthostrophic or heterostrophic; late protoconch not distinct from teleoconch or weakly differentiated; sturdy, moderately thin shelled, generally hyaline and transparent; growth form low spired, sometimes

naticoid; umbilicate, umbilicus open; with or without sculpture; peristome simple; generally without apparent sculpture in adult and with rounded whorl profile; size sometimes exceeding 5.5 mm, generally under 2.5 mm.

Content.- More than 150 nominal species have been referred to Vitrinella and a review of the content of the genus lies beyond the province of this report. Vitrinella is polyphyletic and in need of revision.

Most species are low spired to discoidal and sculpturally simple. These seem congeneric or referable to a plexus of closely related genera. A few involute discoidal species (e.g. Vitrinella margarita Pilsbry and Olsson, 1952) belong in undescribed new genera and seem distinct from Vitrinella on the familial level. Other species with a clearly differentiated protoconch and teleoconch (e.g. Vitrinella cupidinensis Altena, 1966) seem generically distinct from Vitrinella and might best be referred to established families like the Assimineidae.

Remarks.- No species of Vitrinella is described as heterostrophic though heterostrophy is here believed common in the family Vitrinellidae, in the sense that the familial name has conventionally been used. In heterostrophic vitrinellids described below, the axis of coiling of the minute early protoconch is at 90° to the adult axis. The heterostrophic portion of the protoconch, which may be well under .1 mm in height, is completely immersed in the later protoconch and early teleoconch. It is not apparent if specimens are examined casually or at magnifications less than x 100.

If clear boundaries could be drawn between heterostrophic and orthostrophic vitrinellids, it might seem desirable to assign them to separate subgenera or genera. As matters stand, juvenile coiling is not known with certainty in the type species of Vitrinella, and subdivision of the genus is thus impossible unless nomina aperta are used. Heterostrophy and orthostrophy alone are not necessarily a phyletically sound basis for generic subdivision and Vitrinella is here used in a broad sense, including heterostrophic and apparently orthostrophic forms.

Range and Trends.- At the present time, Vitrinella is clearly polyphyletic. Establishment of a temporal range and discrimination of morphologic trends would require an exhaustive evaluation of the nominal content of the family Vitrinellidae and evaluation of species now referred to Tornus and similar non-vitrinellid genera.

Vitrinella meta Corgan, new species

Plate IX, Figures 2, 8

Description.- Vitrinella of low spired growth form; heterostrophic; early protoconch apparently discoidal, completely immersed, axis of coiling at 90° to adult axis; shell translucent, hyaline, sturdy; umbilicate, umbilicus small, delimited by a very sharp flexure, shell thickened along flexure, sides of umbilicus essentially vertical, umbilicus exposing sides of about 3 whorls; spiral sculpture of faint subsutural sulcus, without other sculpture; aperture inclined, with

slight parietal callosity; maximum diameter 1.7 mm at 4.5 whorls along the adult axis, height 1.2 mm, apertural diameter .6 mm, umbilical diameter .5 mm.

Comparisons.- Vitrinella meta Corgan, new species, bears a very strong resemblance to Vitrinella helicoidea C. B. Adams, 1850. In the last two decades, this long-known species has been redescribed by Pilsbry (1946), Pilsbry and McGinty (1946b), and Moore (1964a, unpublished doctoral dissertation). In the recent past, it has also been recorded or illustrated by Pilsbry and McGinty (1945a), Olsson and McGinty (1958), Usticke (1959), and Moore (1965). Since all authors regard the species as orthostrophic, this must here be considered the proper interpretation.

In teleoconch character, Vitrinella helicoidea and V. meta are quite similar but the umbilical margin of V. helicoidea is produced to form a rib, there is generally a spiral rib near the suture, and the umbilicus is fairly broad. Vitrinella meta differs in each of these features. It is narrowly umbilicate and devoid of ribbing.

Derivation of Name.- From the Latin meta, in the sense of a limit, in allusion to the extreme simplicity of the shell.

Occurrence and Abundance.- SP 1-B, -348.8 to 349.0' (1); SP 94 (2); PAL 7 (2).

Holotype.- LSUDGMTC 7384.

Figured Specimen.- LSUDGMTC 7384.

Genus CERAPONS Corgan, new genus

Type Species.- Here designated, Cerapons simulator Corgan, new species.

Diagnosis.- Vitrinellids with columellar margin of the inner lip produced into a long prong which is reflected backwards to form an umbilical callus, development of callus variable, callus not supplemented by extensions of the parietal callus or protrusions from the whorl base; protoconch minute, heterostrophic, early protoconch completely immersed in later protoconch and early teleoconch, later protoconch not clearly differentiated from teleoconch; parietal callus weakly developed, with medial axial channel in some individuals; aperture simple; without sculpture; surface polished; size small.

Content.- Monotypic.

Comparisons.- In conventional classifications of the vitrinellids, all forms with an umbilical callosity are considered part of the Teinostoma stock. A callosity clearly separates Cerapons from Vitrinella and similar forms but does not indicate a relationship to Teinostoma H. and A. Adams, 1853.

In Teinostoma s.s., growth form is discoidal and the periphery is produced, with a spout-like extension of the peristome. The parietal callosity is generally well developed and the umbilical callus in these species is formed by lobate processes originating on the inner margin of the whorl, on the columellar margin, and on the parietal callosity. The parietal callosity, itself, is well developed. There

are many nominal subgenera of Teinostoma and they are believed to be phyletically diverse. Most "teinostomids" have a discoidal growth form or are globular. They tend to be rather heavy shelled and the younger whorls generally override the older. Cerapons Corgan, new genus, is distinct in all these features.

Derivation of Name.- From the Latin cera, in the sense of wax, and pons, bridge, in allusion to the bridging of the umbilicus by a translucent process.

Cerapons simulator Corgan, new species

Plate VII, Figures 1-2, 7-8

Description.- Cerapons of low spired growth form; immersion of the heterostrophic protoconch sometimes incomplete; size at 3.66 whorls along the adult axis 1.64 mm in diameter, height 1.31 mm, apertural diameter .7 mm.

Comparisons.- The species Cerapons simulator most resembles is Teinostoma (Ellipetylus) cocolitoris Pilsbry and McGinty, 1945, now placed in Pseudorotella by Pilsbry (1953, p. 413).

Cerapons simulator and Teinostoma cocolitoris differ in the far greater development of a parietal callosity in the Teinostoma. According to Pilsbry and McGinty (1945a, p. 8), the parietal area contributes to the poorly developed umbilical callosity of T. cocolitoris and their figure shows the umbilical margin of T. cocolitoris sculpturally or texturally differentiated.

Derivation of Name.- From the Latin simulator, in allusion to the similarity of this species to a Teinostoma.

Occurrence and Abundance.- SP 1-B, -350.9 to 351.1 (1) -456.55 to 456.75 (1); SP 5 (2); SP 6 (1).

Holotype.- LSUDGMTC 7387.

Figured Specimens.- LSUDGMTC 7387-7388.

Genus CIRCULUS Jeffreys, 1865

1865. Circulus JEFFREYS, Brit. Conch., v. 3, p. 315.

1953. Ponocyclus PILSBRY, Acad. Nat. Sci., Philadelphia, mon. 8, p. 426. (Type species by original designation Adeorbis beaui Fischer).

Type Species.- By monotypy, Delphinula duminyi Requien (= Valvata striata Philippi).

Diagnosis.- Vitrinellids of small to very large size; protoconch orthostrophic; low spired; growth form discoidal; protoconch and teleoconch not clearly demarcated; whorls generally 5 or less; spiral sculpture of prominent ribs or carinae, with or without accessory spiral ribs; transverse sculpture generally absent; umbilicus wide, open, revealing most of the spire; aperture oblique, essentially circular but modified by sculpture and peristomal attachment; operculum multispiral; size, up to 12.5 mm but generally under 4.5 mm.

Content.- Circulus has nominal species from all seas and all major

subdivisions of the Cenozoic. A revision lies beyond the province of this report.

Comparison.- Discussed under Vitrinellidae.

Status of Ponocyclus.- Pilsbry established Ponocyclus as a subgenus of Cyclostremiscus. It is here treated as a junior synonym of Circulus.

Pilsbry (1953, p. 427) proposed Ponocyclus "merely to find place of a series of species which have been referred to the genera Adeorbis, Skenea, Cyclostrema, Circulus, and Lydiphnis but not agreeing fully enough with either to lead to a consensus of usage. When these groups are better known, the new name may be found superfluous,..."

One prime source of nomenclatorial instability in the complex discussed was a lack of unequivocal knowledge of soft anatomy. Bush (1897) had described and figured the radula of Circulus trilix (Bush) but her text and figures contain significant internal conflicts.

Clearly, Bush considered C. trilix an archaeogastropod because of its size and simple form. She had not expected to find a radula suggestive of other affinities. The radula of Circulus trilix was interpreted as rhipidoglossate but the observations recorded suggest it is taeniglossate. Moore (1964b) concludes that the discussion by Bush favors removal from the Archaeogastropoda and reference to the Rissoacea s.l. This is in accord with results of a dissection of the type species of Circulus (Fretter, 1956) and seems correct if the Rissoacea are very broadly interpreted.

As long as Pilsbry thought that Circulus might be a genus of archaeogastropods (i.e. Pilsbry, 1953, p. 429) he could not refer

more advanced species to Circulus. Hence, Ponocyclus was established. It no longer seems possible to regard Circulus as an archaeogastropod and the type species of Ponocyclus appears referable to Circulus.

Range and Trends.- As a nominal entity, Circulus ranges from Eocene to Recent and is worldwide in distribution. It is too highly polyphyletic to permit discrimination of time-dependent morphologic trends.

Circulus pentagonus (Gabb), 1873

Plate II, Figures 4-5; Plate VII, Figures 3-6

1842. Not Adeorbis supranitidus S. WOOD, Ann. Mag. Nat. Hist., v. 9, p. 530. [= Tornus ? supranitidus (Wood)].

1842. Not Adeorbis tricarinatus S. WOOD, Ann. Mag. Nat. Hist., v. 9, p. 530. [= Circulus tricarinatus (Wood)].

1852. Vitrinella tricarinata C. B. ADAMS, Catalogue Shells at Panama, p. 189.

1863. Vitrinella tricarinata C. B. Adams: CARPENTER, Proc. Zool. Soc. London, 1863, p. 353.

1868. Not Adeorbis supranitidus (Wood) NYST, In Dewalque, Prodrome d'une description geologique de la Belgique, Bruxells, p. 424. [= Circulus supranitidus (Nyst), = Circulus hennei Glibert, 1952, a replacement name].

1871. Not Cyclostrema tricarinatus SMITH, Proc. Zool. Soc. London, p. 737, pl. 75, fig. 26. (= Circulus smithi Bush, 1897).

1873. Cyclostrema pentagona GABB, Trans. Amer. Philosophical Soc., n.s., v. 15, p. 243.

1881. Vitrinella pentagona (Gabb): GABB, Jour. Acad. Nat. Sci., Philadelphia, 2nd ser., v. 8, p. 368, pl. 47, fig. 68.

1885. Skenea trilix BUSH, Rept. Comm. U.S. Fish and Fisheries, 1883, p. 584. (Nomen nudum).

1885. Skenea trilix BUSH, Trans. Connecticut Acad. Arts Sci., v. 6, p. 464, pl. 45, figs. 7-7a.

1889. Adeorbis supranitidus (Wood) DALL, Bull. U.S. Nat. Mus., v. 37, p. 150, pl. 41, figs. 7-7a. (Not A. supranitidus Wood, not A. supranitidus Nyst.)

1889. Adeorbis supranitidus (Wood) Dall: DALL, Bull. Mus. Comp. Zool., v. 18, p. 278.

1892. Adeorbis supranitidus (Wood) Dall: DALL, Trans. Wagner Free Inst. Sci., v. 3, pt. 2, p. 344.

1897. Circulus trilix (Bush): BUSH, Trans. Connecticut Acad. Arts Sci., v. 10, p. 127, pl. 22, figs. 6, 10-10a, 12 a-g, pl. 23, figs. 10, 15.

1904. Adeorbis supranitidus (Wood) Dall: MARTIN, Maryland Miocene, p. 243, pl. 58, figs. 6 a-c.

1907. Circulus cosmius BARTSCH, Proc. U.S. Nat. Mus., v. 32, pl. 173, figs. 8 a-c.

1907? Circulus cerrosensis BARTSCH, Proc. U.S. Nat. Mus., v. 32, p. 173, figs. 9 a-c.

1921. Circulus cosmius Bartsch: DALL, U.S. Nat. Mus. Bull. 112, p. 182.

1922. Circulus pentagona (Gabb): PILSBRY, Proc. Acad. Nat. Sci., Philadelphia, v. 73, p. 397.

1927. Lydiphnis trilix (Bush): DALL, Proc. U.S. Nat. Mus., v. 70, art. 18, p. 124.

1928. "Circulus" pentagonus (Gabb): WOODRING, Carnegie Inst. Washington Pub. 385, p. 441, pl. 37, figs. 16-18.

1934. Lydiphnis trilix (Bush): JOHNSON, Proc. Boston Soc. Nat. Hist., v. 40, p. 76.

1938? Circulus cerrosensis Bartsch: BAKER, HANNA, AND STRONG, Proc. California Acad. Sci., v. 23, p. 235.

1938. Lydiphnis trilix (Bush): AGUAYO, Mem. Soc. Cubana Hist. Nat., v. 12, p. 11.

1939. Circulus tricarinatus (C. B. Adams): STRONG AND HERTLEIN, Allan Hancock Pacific Expeditions, v. 2, p. 185.

1945. Cyclostremiscus tricarinatus (C. B. Adams): PILSBRY AND OLSSON, Proc. Acad. Nat. Sci., Philadelphia, v. 97, p. 271, pl. 28, figs. 3-3b.

1947. "Circulus" trilix (Bush): GARDNER, U.S. Geol. Survey Prof. Paper 142-H, p. 600.

1952. Cyclostremiscus cosmius (Bartsch): PILSBRY AND OLSSON, Proc. Acad. Nat. Sci., Philadelphia, v. 104, p. 83.

1952? Cyclostremiscus cerrosensis (Bartsch): PILSBRY AND OLSSON, Proc. Acad. Nat. Sci., Philadelphia, v. 104, p. 83.

1952. Cyclostremiscus glyptomphalus PILSBRY AND OLSSON, Proc. Acad. Nat. Sci., Philadelphia, v. 104, p. 67, pl. 7, fig. 3.

1953. Cyclostremiscus (?) trilix (Bush): PILSBRY, Proc. Acad. Nat. Sci., Philadelphia, v. 104, p. 83.

1955. Cyclostremiscus (?) trilix (Bush): PERRY AND SCHWENGLE, Marine Shells Western Coast Florida, p. 110, pl. 22, figs. 142 a-d, pl. 49, figs. 336 a-c.

1957. Cyclostremiscus (Ponocyclus) pentagonus (Gabb): WOODRING, U.S. Geol. Survey Prof. Paper 306-A, p. 73, pl. 17, figs. 7-15.

1961. Cyclostremiscus trilix (Bush): WARMKE AND ABBOTT, Caribbean Seashells, p. 60, fig. 14a.

1962. Adeorbis supranitidus Wood: DUBAR, Florida Geol. Survey Bull. 42, p. 66.

Description.- Circulus with three prominent spiral keels in almost all individuals; protoconch elevated, very variable in size; protoconch not clearly demarcated from teleoconch; whorl profile angular to subangular; umbilicus wide, without callus; aperture ovate, modified by spiral sculpture; spiral sculpture very variable, keels always present, occasionally without accessory spiral sculpture, generally with spiral ribs within umbilicus, occasionally with a few spiral cords on spire; without axial sculpture other than growth lines; growth lines occasionally produced, simulating faint axial riblets in the sutural area; parietal callus thin; size very variable, in general from 1.6 to 3.2 mm at 5 volutions.

Comparisons.- Tricarinate sculpture is fairly common in Circulus and a suite of specimens facilitates identification. The Western Atlantic

species most resembling C. pentagonus are C. anthera Gardner, 1947, and C. novicastri (Van Winkle), 1919.

The Miocene C. anthera is more or less tricarinate as a juvenile but develops numerous spiral cords in the adult. The whorl profile then becomes rounded. The Eocene C. novicastri lacks the elevated protoconch of C. pentagonus and has a less well-defined and narrower umbilicus.

Remarks on Synonymy.- Tryon (1887, p. 399) placed Skenea trilix Bush, 1885 in the synonymy of Homalogyra densecostata Jeffreys, 1884. Later authors have not accepted this synonymy. The two taxa do not appear to be confamilial.

Type and reference specimens examined in preparing the synonymy of Circulus pentagonus are listed in Appendix 4.

There is a long history of attempts to separate tricarinate Circulus from the Caribbean Miocene from the Miocene-Recent population of the southern United States.

Woodring (1928, p. 441) interpreted Caribbean Miocene specimens as smaller and more heavily sculptured in the umbilical region. Pilsbry (1922, p. 397) had previously separated them on size alone. More recently, Woodring (1957) combined rate of size increase and constancy of tricarination to differentiate two groups which he treats as species. He characterizes C. pentagonus as small and bicarinate to tricarinate, but generally bicarinate, while C. trilix is consistently tricarinate and larger.

Gabb (1873, p. 243) described Cyclostrema pentagona as

tricarinate. The type specimen, ANSP number 2831, is now missing; however, Gabb's illustration clearly shows a tricarinate shell (Gabb, 1881, pl. 47, fig. 68).

Woodring (1957) is the only author to note bicarinate populations and he states that all specimens from the Lower and Upper Gatun Formation are tricarinate. If all specimens from the Middle Gatun are bicarinate, the two morphologic groups are stratigraphically and perhaps specifically distinct. In any event, the name Cyclostrema pentagona seems best applied to tricarinate populations.

Tricarinate Miocene Circulus from the Atlantic Coast (e.g. Martin, 1904) are clearly conspecific with the living form. Mudlump specimens and specimens listed in Appendix 4 bridge any possible size gap. There does not appear to be a valid basis for separating Caribbean forms on the specific or subspecific level.

In discussing Circulus pentagonus, Woodring (1957) evaluated similar forms. He considered the following species to be Pacific analogues of C. pentagonus: Circulus occidentalis Pilsbry and Olsson, from the Pliocene of Ecuador; C. glyptomphalus (Pilsbry and Olsson), from the Pleistocene of Panama; C. glyptobasis (Pilsbry and Olsson) also from the Panamanian Pleistocene; C. cerrosensis Bartsch, from the California Coast; and C. cosmius Bartsch, another California form. Circulus tricarinatus (C. B. Adams) was excluded from the group since it was described as having faint axial riblets.

Treatment of C. tricarinatus (C. B. Adams) by Woodring (1957) and others is based on the original description and an illustration of the type specimen by Pilsbry and Olsson (1945, pl. 28,

figs. 3-3b). Axial riblets are both described and figured, but they appear to be emphasized growth lines, not discrete sculptural elements. A similar development is noted in mudlump Circulus pentagonus.

Dr. Leo G. Hertlein, California Academy of Science, kindly provided a suite of Recent specimens from the Gulf of Panama that had been identified as Circulus tricarinatus (C. B. Adams) (Strong and Hertlein, 1939, p. 185, California Academy of Sciences Location 27228). Eighty-nine specimens are present. A few show emphasized growth lines that simulate microscopic axial ribs. These fit the original description of Vitrinella tricarinata C. B. Adams and also appear indistinguishable from Atlantic specimens referred to C. pentagonus. Most specimens in the California suite have less prominent growth lines and seem morphologically identical to run-of-the-mill Western Atlantic C. pentagonus (plates 2, 7).

These two nominal species are here considered indistinguishable. Circulus tricarinatus (C. B. Adams), 1852, is the senior name but is preoccupied. Chronologically, Circulus supranitidus (Dall) was the next name applied, but this is also preoccupied. The specific name pentagonus is thus retained.

Circulus pentagonus (Gabb) occurs on both the Atlantic and Pacific coasts of North America. It thus seems provident to re-examine the supposed Pacific analogues of C. pentagonus as listed by Woodring.

Circulus occidentalis Pilsbry and Olsson, 1941, was based on a single individual from the Pliocene Canoa Formation of Punta

Blanca, Ecuador. The type specimen, ANSP 13733, cannot now be located. The original illustration (Pilsbry and Olsson, 1941, pl. 9, fig. 3) strongly suggests that the downward deflection of the peristome, a unique feature, is due to a poorly repaired break. Until the type is located or other specimens collected from the type area, C. occidentalis cannot be evaluated and must be provisionally regarded as distinct from C. pentagonus.

Examination of type material confirms the identity of C. cosmius Bartsch and C. glyptomphalus Pilsbry and Olsson with C. pentagonus. The type specimen of C. cerrosensis Bartsch was not available for study but on the basis of the illustration by Bartsch (1907, p. 173, figs. 9a-c) it is included, with query, in the synonymy of C. pentagonus.

Circulus glyptobasis Pilsbry and Olsson, from the Pleistocene of Ecuador, is regarded as a distinct species. Except for the keels, spiral sculpture is restricted to the umbilical area. The body whorl is much higher and more capacious than that of C. pentagonus. One of the paratypes in ANSP 277268 clearly shows that the peripheral keel of the juvenile, when perfectly preserved, is broad, flat, and bladelike, extending well beyond the whorl margin.

Finally, Cyclostrema quadrilineatum Toula must be evaluated. Woodring (1957, p. 73) considered this a synonym of C. pentagonus and reports that the type is lost. If it is judged from Toula's description and figures (Toula, 1911, p. 497, pl. 31, figs. 11a-c) reference to C. pentagonus seems very doubtful. Still, the type was collected from the Gatun Miocene of Central America and should,

presumably, have reoccurred in the excellent Gatun collections monographed by Woodring. At present, it seems best to exclude Toula's species from the synonymy of C. pentagonus and provisionally regard it as a somewhat problematic and rare species.

Geographic Distribution.- Cape Hatteras to the Antilles in the Atlantic, Gulf of Panama in the Pacific.

Stratigraphic Distribution.- Middle Miocene and younger, Antilles to Maryland. Pleistocene of Ecuador.

Bathymetric Distribution.- 3-17 fathoms.

Occurrence and Abundance.- SP 1-B, 350.9-351.1' (1). 455.75-455.95' (1); SP 6 (2); SP 94 (2); PAL 7 (2).

Figured Specimens.- LSUDGMTC 7382-7383.

Genus EPISCYNIA Moerch, 1875

1875. Episcynia MOERCH, Malak. Blaet, v. 22, p. 155.

Type Species.- By monotypy, Architectonica (Episcynia) inornata (Orbigny) (= Solarium inornatum Orbigny).

Diagnosis.- Shell low spired, with a clearly differentiated peripheral keel; keel generally with microscopic denticulations formed by incised growth lines; with or without accessory spiral ribs or keels on the spire; without axial sculpture; protoconch 1-1.5 whorls; teleoconch generally about 4 whorls; umbilicate, umbilicus narrow, deep, steep

sided, bounded by an umbilical keel; umbilicus exposing most whorls, generally showing trace of umbilical keel; shell moderately thick, not massive; body whorl generally tending to uncoil; periostracum, where known, with spiral fringes of hair-like filaments above and below the periphery; size, under 6 mm.

Content.- The nominal content of Episcynia is listed in Table 15 and a register of type and reference specimens examined is given in Appendix 4.

Range and Trends.- One species occurs in the Eocene and four in the Miocene of the Caribbean-Gulf of Mexico area. Several species occur in Recent faunas of both the Atlantic and Pacific coasts. Species do not form morphologic clusters.

Episcynia inornata (Orbigny), 1841

Plate VIII, Figures 1, 4-5

1841. Solarium inornatum ORBIGNY, In Sagra, "Ile d'Cuba," Mollusques, p. 67.

1859? Architectonica gemma HOLMES, Post Pleiocene Fossils South Carolina, p. 92, pl. 14, figs. 6-6b.

1875. Architectonica (Episcynia) inornata (Orbigny): MOERCH, Malak. Blaet., v. 22, p. 155.

1887. Architectonica (Episcynia) inornata (Orbigny): TRYON, Man. Conch., v. 9, pl. 6, figs. 32-33.

1961. Episcynia inornata (Orbigny): WARMKE AND ABBOTT, Carib. Seashells, p. 61, fig. 14c.

Table 15

NOMINAL CONTENT OF EPISCYNIA[1]

Solarium bastropensis Harris, 1895

Episcynia bolivari Pilsbry and Olsson, 1946

Adeorbis carinata Gabb, 1873

Episcynia devexa Keen, 1946

Architectonica gemma Holmes, 1859[2]

Solarium inornatum Orbigny, 1842

Episcynia mauryi Gardner, 1947

Episcynia megalia Woodring, 1957

Vitrinella (Episcynia ?) multicarinata Dall, 1889

Discopsis ? naso Pilsbry and Johnson, 1917[3]

Circulus nicholsoni Strong and Hertlein, 1939

[1]All species seem properly referred to Episcynia.

[2]For synonymic treatment, see text.

[3]An unnecessary replacement name for Adeorbis carinata Gabb.

1965. Episcynia inornata (Orbigny): RICE AND KORNICKER, Pub. Inst. Mar. Sci., v. 10, p. 118, pl. 1, fig. 20.

Description.- Episcynia with a single keel on the finely serrated periphery and a coarsely serrated umbilical keel; peripheral keel exposed on entire teleoconch; teleoconch and protoconch sometimes separated by a minute varix; initial whorl of teleoconch sometimes tending to override protoconch; growth lines faint on apical surface, on adapical surface growth wrinkles are low and, in part, form continuous ridges from the periphery to the umbilicus; body whorl slightly tending to uncoil; size, about 2.8 mm at 3.5 adult whorls.

Comparisons.- Moore (1964a) placed Vitrinella (Episcynia ?) multicarinata Dall in the synonymy of E. inornata. Dall did not illustrate his species, and knowledge of it comes principally from Pilsbry and McGinty (1946b), Pilsbry (1953), and Maury (1922). As the name suggests, E. multicarinata (Dall) has more than one carinae: a well-developed peripheral carina, less well-developed carinae above and below the periphery; and, of course, an umbilical carina.

Dall (1892, p. 419) suggested that his Vitrinella multicarinata was conspecific with Architectonica gemma Holmes, 1859. Most subsequent workers have accepted this but none has proposed the required nomenclatorial change. The equivalence of Episcynia gemma and E. multicarinata is here questioned. Holmes (1859, p. 92) describes and illustrates an Episcynia without accessory carinae on the spire.

Western Atlantic unicarinate and tricarinate Episcynia are

believed specifically distinct. Possibly, presence or absence of accessory carinae varies from individual to individual, but occurrence of unicarinate and tricarinate species in the Western Atlantic area since Miocene time suggests that ribbing is a significant character. Episcynia mauryi Gardner is an example of a Miocene unicostate species and E. carinata (Gabb) is a Miocene tricostate species. Sculptural characteristics, maximum size, and proportions of the umbilicus require that these taxa be treated as specifically distinct from their modern analogues: the tricostate E. multicostata (Dall) and the unicostate E. ornata (Orbigny).

Known features of the post-Pleistocene E. gemma (Holmes) do not seem significantly different from the modern E. inornata and the names are provisionally regarded as synonyms.

Geographic Distribution.- Recent: Antilles and Campeche Bank. Pleistocene: South Carolina ?.

Bathymetric Distribution.- 30-250 feet.

Occurrence and Abundance.- SP 94 (2).

Figured Specimen.- LSUDGMTC 7343.

SECTION C: PYRAMIDELLIDS

Mudlump Fauna.- Collections examined contain 295 specifically determinate pyramidellids. Four subfamilies are represented. The Turbonillinae are the principal group with 20 species. All are described as new. Twelve species are assigned to Turbonilla (Turbonilla) and the remainder to Turbonilla (Pyrgiscus).

The Odostomiinae are represented by one new genus, two established genera, three new species that are formally described, and a fourth for which no name is advanced. Seventy specimens are referred to the Odostomiinae.

Twelve mudlump specimens are placed in the Chrysallidinae. Three Chrysallida (Chrysallida) are treated as nomina aperta. One new Chrysallida (Fargoa) is described.

The Pyramidellinae are the least abundant subfamily. Ten specimens are assigned to three species. One species is long known; the other two are described as new.

Summarizing all subfamilies, collections contain 30 species of pyramidellids. Thirty are new.

Neontology.- In any group, systematic description assumes and requires knowledge of more than a long-dead shell. Specific and generic descriptions involve an assessment of all that is known of a taxon. In a group strongly divergent from normal patterns of categorical interrelationship, and in groups characterized by an abnormal incidence of new taxa, it is especially desirable to evaluate conchological differences with great care. In a final analysis, descriptions should

be reasonable in light of some tenable hypothesis.

Aspects of neontology that have special pertinence in understanding pyramidellid categorical ratios and units are briefly reviewed below.

Larval Ecology.- Virtually every pyramidellid has an obviously heterostrophic larval shell. Larvae are also pelagic. Knowledge of pyramidellid larvae comes primarily from Lebour (1932; 1936; 1937) and a commentary by Thorson (1946) is essential to use of Lebour's work.

Lebour principally studied Odostomia eulimoides. She observed it in plankton, tried to raise it in the laboratory, described eggs and larvae in great detail, and discussed secretion of the early whorls. She also studied other species including a Chrysallidinae, Chrysallida decussata. All are planktonic in the young and inversion of the coiling axis occurs in the planktonic stage.

In Odostomia eulimoides, the larval shell is not obviously heterostrophic. Its pelagic phase is reduced and the larva is small. Though the shell is heterostrophic, a globular shape, small size, and immersion of early whorls make the coiling discordance unnoticeable.

Fretter and Graham (1962, p. 662) list other pyramidellids in which heterostrophy is not apparent and Robertson and Orr (1961) discuss one species in detail. This species, Odostomia chitonicola (Smith), is not heterostrophic, though its orthostrophic protoconch may be caused by a telescoping of growth stages. Orthostrophy plus a wide range of growth stages resident on a single host suggests that the larva is not pelagic. Odostomia chitonicola is the only more or less clear example of an entirely benthonic pyramidellid.

All mudlump pyramidellids are clearly heterostrophic. It appears each species can occur in areas where its population is too diffuse to permit effective breeding.

Food and Feeding.- There are two sources of data on the food of pyramidellids: laboratory study and observation in nature. Data from both sources are summarized in Table 16.

One prime limiting factor underlies all laboratory studies. The species used are widely distributed, have easily sampled habitats, are common animals, and exist in large populations near north-temperate biological laboratories. Truly representative pyramidellids are endemic to small areas, are known from small populations, occur in hard-to-sample habitats, and have a more southern distribution.

To a lesser degree, other factors also limit the utility of laboratory data. The laboratory environment is totally foreign to the animals, specimens are starved prior to testing, a restricted range of foods is offered, and the economic significance of pyramidellid parasitism is the focus of study.

Observations in the natural environment are casual and merely imply a host-predator relationship. Large mollusks, echinoderms, and other recorded hosts support a flourishing epifauna of worms, small mollusks, arthropods, etc. Occurrence of a pyramidellid on larger animals does not imply a feeding relationship with the species that affords purchase. Feeding must be observed. It is sometimes difficult to separate observation and inference.

TABLE 16

PYRAMIDELLIDS AND THEIR HOSTS[1]

Pyramidellid	Host	Authority
Subfamily PYRAMIDELLINAE		
Pyramidella dolobratus	Worm	Robertson and Orr (1961)
	Sand Dollar	Robertson and Orr (1961)
Otopleura mitralis	Hemicordate	Robertson and Orr (1961)
Subfamily TURBONILLINAE		
Turbonilla elegantissima	Worms	Fretter and Graham (1949)
Turbonilla hofmani	Algae	Laseron (1951)
Turbonilla jeffreysi	Coelenterate	Robertson and Orr (1961)
Turbonilla rufescens	Worm	Marshall (1900)
Subfamily CHRYSALLIDINAE		
Chrysallida dianthophylla	Worm	Wells and Wells (1961)
Chrysallida seminuda	Sea Squirt	Allen (1958)
	Aequipecten	Boss and Merrill (1965)
	Crassostrea	Boss and Merrill (1965)
	Crepidula	Boss and Merrill (1965)
	Crucibulum	Boss and Merrill (1965)
	Mercenaria	Boss and Merrill (1965)
	Modiolus	Boss and Merrill (1965)
	Placopecten	Boss and Merrill (1965)
Chrysallida obtusa	*Ostrea*	Cole and Hancock (1955)
Spiralina spiralis	Worm	Fretter and Graham (1962)
Menestho bisuturalis	Algae	Allen (1958)

Pyramidellid	Host	Authority
	Aequipecten	Boss and Merrill (1965)
	Bittium	Scheltema (1965)
	Brachidontes	Boss and Merrill (1965)
	Crassostrea	Loosanoff (1956)
	Crepidula	Boss and Merrill (1965)
	Crucibulum	Boss and Merrill (1965)
	Littorina	Scheltema (1965)
	Mercenaria	Boss and Merrill (1965)
	Modiolus	Boss and Merrill (1965)
	Placopecten	Boss and Merrill (1965)
Menesthos (Liostomia) clavula	Coelenterate	Robertson and Orr (1961)
Menestho impressa	Worm	Allen (1958)
	Tunicate	Allen (1958)
	Bittium	Allen (1958)
	Crassostrea	Hopkins (1956)
	Crepidula	Allen (1958)
	Odostomia ?	Allen (1958)
	Triphora	Allen (1958)
	Urosalpinx	Allen (1958)
Menestho trifida	Mya	Allen (1958)
Subfamily ODOSTOMIINAE		
Odostomia chitonicola	Dinoplax	Robertson and Orr (1961)
Odostomia conoidea	Worm	Fretter and Graham (1962)
Odostomia eulimoides	Ostrea	Cole and Hancock (1955)
	Pecten	Fretter and Graham (1962)
	Chlamys	Fretter and Graham (1962)
Odostomia indistincta	Worm	Laseron (1951)

Pyramidellid	Host	Authority
Odostomia lukisi	Worm	Fretter and Graham (1949)
Odostomia perezi	Worm	Gardiner (1934)
Odostomia scalaris	*Mytilus*	Fretter and Graham (1949)
	Hydrobia	Gardnier (1934)
	Rissoa	Ankel and Christensen (1963)
Odostomia unidentata	Worm	Fretter and Graham (1949)

[1]Generic assignments of species are, in part, original and the subfamilial ordering is original. Specific names used follow authorities cited. Many are homonyms, some have synonyms, no rectification is attempted. References cited are not necessarily original records. Secondary sources simplify the bibliography.

Students of pyramidellid food and feeding are sometimes unfamiliar with classification. They do not recognize valid generic and familial level taxa. Some may not realize that modes of feeding differ. Turbonillinae feed by extruding the proboscis onto the substrate. It is extended beneath the sediment surface and erected near a host (Fretter and Graham, 1962). Typical Odostomiinae extend the proboscis through the water till the host is reached. Different muscular arrangements are required and the surface of muscle attachment is different in the various pyramidellid subfamilies.

Feeding in Pyramidellinae is unknown and it seems to be quite variable but generally odostomid-like in the Chrysallidinae.

Shell morphology and observations recorded in Table 16 suggest pyramidellid subfamilies differ in their range of prey and prey preference.

There is current controversy over the host-specificity of pyramidellids. Few would argue that some are clearly host specific (e.g. Robertson and Orr, 1961). Others appear to be, for they spend most of their lives on or within the exoskeleton of a particular host (e.g. Wells and Wells, 1961). Occasional observations suggest pyramidellids eat vegetal food. Laboratory study shows some species accept a broad diet of animal foods.

Data are not adequate for a definitive description of pyramidellid diets. There are two extreme views:

> "The evidence...contributed by workers in the field and cited here indicates that the Pyramidellidae do not appear

> to be a family of host specific ectoparasites. Perhaps they are carnivorous creatures--scavengers, or plain predators." (Allen, 1965, p. 170).
>
> "...host-parasite specificity...affords the first reasonable explanation of the existence of so many closely allied sympatric species..." (Berry, 1954, p. 25).

Basic anatomical features appear to be fairly uniform throughout the Pyramidellidae and require that all pyramidellids be interpreted as obligate ectoparasites. Geographic distribution, laboratory experiments, and great abundance in the natural environment all strongly suggest that the more common and widespread pyramidellids are obligate, vagrant ectoparasites that can and do accept a number of hosts.

Rare pyramidellids with a restricted geographic distribution are probably nearly host specific. These are the average species.

Reproduction.- Dissections of Turbonillinae, Chrysallidinae, and Odostomiinae (Fretter, 1951; Fretter and Graham, 1949; 1962) show a comparable reproductive system in all subfamilies. Individuals are simultaneous hermaphrodites. While self-fertilization may occasionally be possible, it seems unlikely.

The subfamily Pyramidellinae is anatomically unknown but is believed to be another group of simultaneous hermaphrodites.

Since sustenance of pyramidellid populations requires sexual intercourse, species must exist in relatively dense concentrations in breeding areas. The pelagic larvae, discussed above, suggest that some individuals of representative species may grow to maturity

in areas where a breeding population is not maintained.

Distribution, Diversity and Abundance.- In the words of Fretter and Graham (1949, p. 493), the pyramidellids "make a brave show" in the faunal lists of the world. Though they occur in antarctic and arctic faunas, they are most abundant in warmer seas. Pyramidellids are the fourth most taxonomically diverse group in the abyssal fauna (Clarke, 1962, p. 3) but they are principally shallow water organisms.

According to Bartsch (1955, p. 6) the Pyramidellidae is the second most taxonomically diverse familial group in the marine molluscan fauna. Other authors place it slightly lower (Taylor and Sohl, 1962) but in all cases the relative diversity of pyramidellids is both great and vastly underrated. The Pyramidellidae is a close-knit unit, a valid family, and the larger families with which the Pyramidellidae are compared lack this degree of unity.

The ancestry and early evolutionary history of the pyramidellids is little known. A review of the Zoological Record and comparable indices to the earlier literature suggest more than 8,000 species have been described from Cretaceous and younger faunas. Most have been assigned to three genera: Pyramidella, Turbonilla (= Chemnitzia), and Odostomia.

Authorities differ in the significance assigned this vast number of nominal species. Some (e.g. Weller, 1955; Abbott, 1955; 1958) stress the evils of "splitting" and question quality of taxonomic work. Others (e.g. Bartsch, 1955) stress diversity of form and appear to regard prior descriptions of diversity as essentially valid.

Subclass OPISTHOBRANCHIA Milne-Edwards, 1848

1848. Opisthobranches MILNE-EDWARDS, Ann. Sci. Nat. Zool., ser. 3, v. 9, p. 107.

Diagnosis.- Gastropods in which anatomical complexities resulting from torsion are generally simplified; marine; hermaphrodite; without esophageal glands; generally with auricle posterior to ventricle and anterior to gills; shell frequently reduced or absent, where present generally heterostrophic and with a plicate columella.

Order ENTOMOTAENIATA Cossmann, 1896

1896. Entomotaeniata COSSMANN, Essais Paleoconchologie Comparee, v. 2, p. 5.

Diagnosis.- Ophisthobranchs of high spired growth form; shell bearing; generally with spiral sculpture on the columella and a heterostrophic protoconch; primitively with a labial sinus.

Remarks.- Taylor and Sohl (1962) suggest reviving the Entomotaeniata of Cossmann to include two superfamilies, the Pyramidellacea and the Nerineacea. This group, formally characterized above, seems to be a practical taxon. Alternate classifications in current use treat the Pyramidellacea as the only superfamily of an undiagnosed order or as Incertae Sedis (Morton, 1958, p. 177; Knight et al. 1960, p. 322).

Superfamily PYRAMIDELLACEA Gray, 1840

1840. Pyramidellidae GRAY, Synopsis Content Brit. Mus., Ed. 42, p. 148.

Diagnosis.- Entomotaeniatids of pupate to bulbous or acicular growth form; ingestive and digestive systems specialized for ectoparasitism and egestive system sometimes simplified by symbiosis with ciliate protozoans, with simple and short intestine, reduced stomach, without radula, with jaws modified into a piercing organ, with a buccal pump and extremely elongate proboscis ending in a sucker; penis very elongate, with numerous ganglia, everted through loop in principal nerve ring; auricle anterior to ventricle; almost always heterostrophic; generally with plicate columella and most frequently with externally apparent parietal dentition; size range from about 1 to over 18 mm.

Remarks.- The generic name Pyramidella Lamarck, 1799, would ordinarily be considered a junior objective synonym of Obeliscus Humphrey, 1797, and Plotia Roeding, 1798. Both Pyramidella and Obeliscus are monotypic for Trochus dolabratus Linne. By subsequent designation of Pilsbry and Bequaert (1923, p. 36), the type of Plotia Roeding is Plotia lineata Roeding. As Pilsbry (1950, p. 68) and others have noted, this name is a synonym of Trochus dolabratus Linne, the type species of Pyramidella Lamarck, 1799.

The generic name Pyramidella Lamarck, 1799, and the familial name Pyramidellidae Gray, 1840, have been added to the official lists

of the international Commission on Zoological Nomenclature (Hemming, 1956a; 1956b). Obeliscus Humphrey, Plotia Roeding, and familial names synonymous with Pyramidellidae Gray have been added to the indices of rejected names (Hemming, 1956b; 1958).

Family PYRAMIDELLIDAE Gray, 1840

1840. Pyramidellidae GRAY, Synopsis Content Brit. Mus., Ed. 42, p. 148.

Diagnosis.- As for Superfamily.

Subfamily PYRAMIDELLINAE Gray, 1840

1840. Pyramidellidae GRAY, Synopsis Content Brit. Mus., Ed. 42, p. 148.

Diagnosis.- Pyramidellids of moderately high spired to acicular growth form; many whorled; protoconch heterostrophic; parietal dentition and columellar sculpture of from one to three elements, strongly developed in adult; generally sturdy, rarely ornate; protoconch either immersed or emergent; size medium to large, generally over 4 mm.

Remarks.- Saurin (1948, p. 64) uses the Syrnolinae Saurin for uniplicate Pyramidellinae.

Genus LONGCHAEUS Moerch, 1875

1875. Longchaeus MOERCH, Malak. Blaet., v. 22, p. 158.

Type Species. By subsequent designation, Dall and Bartsch 1904, Pyramidella punctata Chemnitz (= Pyramidella punctata Schubert and Wagner).

Diagnosis.- Pyramidellids of high spired growth form; not umbilicate; with many whorls; whorl profile flat; with three columellar folds and three parietal teeth in late adult; with a peripheral sulcus; with or without microscopic axial and spiral sculpture; with a basal fasciole; size, generally between 5 and 15 mm.

Remarks.- The type designation by Dall and Bartsch (1904, p. 4) is valid. The type species was listed as Obeliscus (Longchaeus) candidus Chemnitz by Moerch (1875, p. 158) and is actually Pyramidella punctata Schubert and Wagner, 1829.

Publication was in a fragmentary twelfth volume of the first Martini-Chemnitz "Neues Systematischen Conchylien-Cabinet." The first eleven volumes of the first Martini-Chemnitz lack status in Zoological Nomenclature (Hemming, 1944; 1954). The fragmentary twelfth volume is rare, virtually unknown, not even included in the index to the first Martini-Chemnitz. It is unaffected by action of the International Commission on Zoological Nomenclature and remains a valid source of names.

Longchaeus candidus (Moerch), 1875

Plate IX, Figure 10

1875. Obeliscus (Longchaeus) candidus (Meuschen) MOERCH, Malak. Blaet., v. 22, p. 158.

1885. Longchaeus candidus (Meusch): DALL, U.S. Geol. Survey Bull. 24, p. 145.

1889. Pyramidella (Longchaeus) candida (Moerch): DALL, U.S. Nat. Mus. Bull. 37, p. 128.

1892. Odostomia (Longchaeus) candida (Moerch): DALL, Trans. Wagner Free Inst. Sci., v. 3, p. 247.

1922. Pyramidella (Longchaeus) candida (Moerch): MAURY, Bull. Amer. Paleont., no. 38, p. 17.

1934. Pyramidella (Longchaeus) candida (Moerch): JOHNSON, Proc. Boston Soc. Nat. Hist., v. 40, p. 86.

1959. Pyramidella candida (Moerch): USTICKE, Check-list Marine Shells St. Croix, p. 86.

1961. Pyramidella candida (Moerch): WARMKE AND ABBOTT, Caribbean Seashells, p. 147.

Description.- Longchaeus of fairly large size, reaching 15-18 mm at 12 or more post-protoconch whorls; generally without spiral microsculpture, with axial sculpture of microscopic lines within the peripheral sulcus and low, dense axial nodes at shoulder; interior of outer lip with occasional, isolated denticles in late adult; shell thickness variable, generally thin in region of growth; peripheral sulcus narrow, deep, with U-shaped bottom.

Occurrence and Abundance.- PAL 7 (5).

Figured Specimen.- LSUDGMTC 7356.

Genus SYRNOLA A. Adams, 1860

1860. Syrnola A. ADAMS, Ann. Mag. Nat. Hist., Ser. 3, v. 5, p. 405.

Type Species.- By monotypy, Syrnola gracillima A. Adams.

Diagnosis.- Pyramidellids of fairly large size; high spired to acicular growth form; without umbilicus; generally without sculpture, occasionally with microscopic spiral striae; columella with a single plication; generally with an externally apparent parietal tooth; size range generally 4 to 18 mm.

Remarks.- Bartsch (1909a) and others who follow him give a long synonymy for Syrnola: Anisocycla Monterosato, 1800 (sic), Baudonia Bayan, 1873, Raphium Bayan, 1873, and Aciculina Deshayes, 1864. This plexus of name is part of an exquisite nomenclatorial problem; however, none of the nominal genera bears a close resemblance to Syrnola.

Evaluation of described Western Atlantic Syrnola is somewhat hampered by a lack of illustrations for Pyramidella fernandina, P. floridana, and P. georgiana. Authorship of these species is generally attributed to Dall (e.g. Johnson, 1934). Actually, they were described by Bartsch (In Dall, 1927). Word descriptions seem adequate to assure that these taxa are not present in the mudlump fauna.

Syrnola ampla Corgan, new species

Plate IX, Figure 1

Description.- Syrnola of very high spired growth form, very slender, uniformly expanding throughout ontogeny; protoconch not immersed, helicoid, about 3 whorls, at 90° to adult axis; whorls of teleoconch very flat-sided; shell very thick; sculpture absent; suture appears incised; reaches 3.24 mm in length and 1.04 mm in width at about 7 post-protoconch whorls; adult with at least 9 post-protoconch whorls; aperture broken in all specimens.

Comparisons.- The extremely elongate growth form, constant rate of expansion, and flat-sided whorls of Syrnola ampla set it off from all Syrnola of the Western Atlantic. The nearest species are Turbonilla smithi Verrill and Turbonilla tryoni Bartsch. Bartsch (1909a, p. 71, pl. 11, figs. 11, 15) treated Verrill's species at length and placed it in Pyramidella (Syrnola). It is close to T. tryoni Bartsch which Bush (1909) referred to Pyramidella (Syrnola). Both of these northern species have a slightly concave whorl profile and are thus distinct from Syrnola ampla. In addition, neither appears to have the thick shell of this species.

Remarks.- Though Syrnola ampla Corgan, new species, is not known from an intact, mature specimen, the genus as a whole shows little ontogenetic variation in sculpture or growth form. Size is, thus, the only significant difference between adults and juvenile. This is variable within and between populations. Material at hand permits characterization

of S. ampla in sufficient detail to insure recognition by future workers.

Derivation of Name.- From the Latin ampla, in the sense of ample, in allusion to the ample walls.

Occurrence and Abundance.- PAL 7 (4).

Holotype.- LSUDGMTC 7396.

Figured Specimen.- LSUDGMTC 7396.

Syrnola meridiana Corgan, new species

Plate IX, Figure 7

Description.- Syrnola of high spired growth form; slender; apical area mucronate, first 1 to 2 whorls rapidly expanding, later whorls slowly expanding; protoconch not completely immersed, at about 120° to adult axis, helicoid, few whorled; without spiral sculpture; with irregular prosocline axial undulations that resemble rudimentary ribbing; whorl base sharply rounded, articulation of succeeding whorls more or less confined to base of earlier; parietal tooth not prominent; size at 6.5 post-protoconch whorls 3.04 mm in length and 1.00 mm in width; aperture somewhat patulous, about .40 x .72 mm.

Comparison.- Species comparable to S. meridiana are not well understood. The most similar group is a number of species that have been called Syrnola fusca and attributed to C. B. Adams (1839, p. 282, pl. 4, fig. 9).

Clench and Turner (1950, p. 283, pl. 38, figs. 20-21) recently selected a lectotype. Both the lectotype and Adams' original figure have a mucronate apex, lack apparent spiral sculpture, have a rounded and inflated whorl profile, a semicircular aperture, a parietal tooth, and a rapid rate of expansion. A specimen illustrated by Tryon (1885, p. 356, pl. 78, fig. 41) is the same and one described by Bartsch (1909a, p. 73, pl. 11, fig. 4) is essentially similar but has faint spiral sculpture. All seem conspecific.

Syrnola fusca resembles S. meridiana, new species, in apical character only. All S. fusca expand more rapidly and have a semicircular aperture.

LaRocque (1953, p. 140) and most earlier authors considered the range of Syrnola fusca as Prince Edward Island to Florida. Warmke and Abbott (1961, p. 147, pl. 26, fig. m) extended the range to the West Indies. The specimen they illustrate cannot be assigned to a described species. This unnamed species resembles S. meridiana in whorl profile, shares the mucronate apex, and, as far as is known, reaches about the same length. It is broader than S. meridiana and has a semicircular aperture. The two do not seem conspecific.

Derivation of Name.- From the Latin meridiana, southern, in allusion to the southern distribution of this mucronate Syrnola.

Occurrence and Abundance.- PAL 7 (1).

Holotype.- 7357.

Subfamily TURBONILLINAE Tryon, 1885

1885. Turbonillidae TRYON, Man. Conch., v. 8, p. 317.

Diagnosis.- Pyramidellids of high spired to acicular growth form; many whorled, slowly expanding; generally with moderately sturdy shell, not massive; frequently without columellar plication and generally without externally apparent parietal tooth; sculptured at some ontogenetic stage; protoconch heterostrophic, generally emergent; generally with a complete peristome and without an umbilicus; size small to large, generally over 2.5 mm in adult.

Genus TURBONILLA Risso, 1826

1826. Turbonilla (Leach ms) RISSO, Hist. Nat. Europe Merid., v. 4, p. 224.

1840. Chemnitzia ORBIGNY In Webb and Berthelot, Hist. Nat. Isles Canaries, p. 77 (Type species by monotypy, Melania campanellae Philippi).

1858. Not Elusa WALKER, List Spec. Lep. Insects Brit. Mus., v. 16, p. 202.

1861. Elusa A. ADAMS, Ann. Mag. Nat. Hist., ser. 3, v. 7, p. 297 (Type species by monotypy, Elusa teres A. Adams).

1861. Euturbonilla SEMPER, Arch. Natur. Fred. Meck., p. 354 (Apparently no type species has ever been designated).

1874. Microbeliscus SANDBERGER, Land u. Suessw. Conch. d. Vorwelt, p. 690 (Type species by original designation, Turbonilla inaspectus Fuchs).

1892. Strioturbonilla SACCO, Boll. Mus. Zool. Anat. Comp. Torino, v. 7, p. 55 [Type species by original designation, Odostomia sigmoidea Jeffreys, not Turbonilla alpina Sacco as stated by Dall and Bartsch (1904)].

1892. Pyrgolampros SACCO, Reale Accad. Sci. Torino, mem., ser. 2, v. 42, p. 667 (Type species by monotypy Pyrgolampros mioperplicatus Sacco).

1906. Nisiturris DALL AND BARTSCH, Proc. U.S. Nat. Mus., v. 30, p. 341 (Type species by original designation Chemnitzia crystallina Dunker).

Type Species.- By subsequent designation, Herrmannsen 1852, Turbonilla costulata Risso (not T. costulata Verrill = T. mighelsi Bartsch).

Diagnosis.- Turbonillinae with prominent axial ribs that are frequently reduced or absent on the base; with or without axial microsculpture; spiral sculpture, if present, less prominent than axial.

Remarks on Type Designation.- The type designation here recognized is not one of those usually cited. It appears that Palmer (1958, p. 251) is the only modern author to follow Herrmannsen's designation.

The species that are most often cited as the type of Turbonilla are Turbo lacteus Linne, by several European workers (e.g. Glibert, 1952, p. 58), Turbonilla typica Dall and Bartsch, by most American workers (e.g. Bartsch, 1955, p. 18), and Turbonilla plicatula Risso by many others (e.g. Laseron, 1959, p. 232).

Apparently, the earliest fixation of a type species for

Turbonilla was by Gray (1847, p. 160). The species selected, Turbo elegantissimus Montagu, did not appear under Turbonilla in the original introduction of the generic term and, thus, cannot be validly established unless it is a senior synonym of one or more of the nominal species that form the original content of the genus. Turbonilla costulata Risso is roughly similar to T. elegantissima (Montagu). On this basis, it has sometimes been cited as the type.

Recent distributional studies suggest (Fide Palmer, 1958) that the southern limits of T. elegantissima (Montagu) lie to the north of the area involved in Risso's study. Thus, it seems most unlikely that T. elegantissima (Montagu) and T. costulata Risso are synonymous names. The type designation by Gray does not appear to be valid.

In 1903, Dall and Bartsch (p. 269) cited Turbonilla typica Dall and Bartsch as the type species of Turbonilla. The specific name originated as a replacement for Turbonilla plicatula Risso which Dall and Bartsch felt was a junior homonym of Turbo plicatulus Linne. Internal evidence in Dall and Bartsch (1903) suggests it was published in 1902 but Hertlein (1964) recently confirmed the 1903 date.

Most subsequent workers have rejected the homonymy between Turbonilla plicatula Risso and Turbo plicatulus Linne. On this basis, Turbonilla plicatula Risso is, thus, sometimes cited as the type species of Turbonilla (e.g. Gardner, 1935, p. 310).

Modern European citations of Turbo lacteus Linne as the type of Turbonilla Risso appear to arise from several sources. In 1883, Bucquoy, Dautzenberg, and Dolfuss designated this species as

the type of Turbonilla. Their work has generally been overlooked and does not appear to be the common source for citations. The species does not appear in Risso's original content and no synonymy is given. Bush (1899, p. 147) discusses T. lactea and later (1909) interprets her discussion as a type designation. In modern terminology, it is not.

The common source for citations of Turbo lacteus as the type of Turbonilla seems to be the works of Cossmann, who appears to use varying interpretations of Gray's designation. Early works (i.e. Cossmann, 1888, p. 109) cite Turbonilla elegantissima (Montagu) without providing an authority for the citation. Later works (e.g. Cossmann, 1921, p. 278) cite Turbonilla lactea (Linne) and, again, no authority is cited.

The name Turbonilla elegantissima (Montagu) is carried as a junior synonym of T. lactea (Linne) in Monterosato (1884, p. 91) and this work is a standard reference. Citation of T. lacteus (Linne) as the type of Turbonilla thus seems to be an acceptance of Monterosato's synonymization of T. lactea with T. elegantissima, combined with an acceptance of Gray's type designation, and further combined with an acceptance of the identity of T. lactea (Linne) and T. costulata Risso. Monterosato, himself, (1884, p. 91) questioned this last synonymization. In this context it is interesting to note that Wrigley (1940, p. 13) cites T. costulata as the type and Monterosato 1884 as the designator.

Recently, Iredale and McMichael (1962, p. 85) cite Turbonilla striata (Montagu) as the type of Turbonilla and credit the designation

to Gray, 1847, p. 152. Montagu's species is not in Risso's list and no explanation is offered. While it is possible to rationalize this designation, it appears to involve a longer series of assumptions than Cossmann's usage of Turbo lacteus.

Varying citations of Turbonilla typica Dall and Bartsch, Turbonilla elegantissima (Montagu), Turbonilla costulata Risso, Turbonilla lactea (Linne), Turbonilla striata (Montagu), and Turbonilla plicatula Risso as the type species of Turbonilla have helped to prevent development of a clear concept of the genus. Actually, most of these nominal species are poorly known and most appear to have rather similar adult sculpture.

The designation of a type species by Herrmannsen, cited above, is valid and appears to be the earliest valid designation. It unequivocally fixes the type as Turbonilla costulata Risso.

Remarks.- Turbonilla exceeds most genera in subgeneric and specific content. Two subgenera are recognized in the mudlump fauna: Turbonilla (Turbonilla) and Turbonilla (Pyrgiscus). Some workers might place mudlump species in Chemnitzia Orbigny, Strioturbonilla Sacco, or Nisiturris Dall and Bartsch. These subgenera are not founded on taxonomically significant characters.

Descriptions of turbonillids generally include a lengthy word portrait of the aperture. In this report, apertures are described in illustrations only. Variations within turbonillid lineages are subtle and word portraits fail to make adequate distinctions.

TURBONILLA (TURBONILLA) Risso, 1826

1826. Turbonilla RISSO, Hist. Nat. Europe Merid., v. 4, p. 224.

Type Species.- As for genus.

Diagnosis.- Turbonilla with rounded axial ribs limited at periphery or becoming obsolete on base; spiral sculpture of closely spaced microscopic to small incised lines may be present; whorl profile flat-sided; suture appressed or incised; shoulder not tabulated.

Remarks.- The synonymy of Turbonilla, given above, pertains to the nominate subgenus only. It seems that spiral sculpture, when present in Turbonilla (Turbonilla), is always fairly dense and incised lines are rather equally spaced.

Many Western Atlantic species described as Turbonilla and Chemnitzia remain unillustrated or are known only from very stylized drawings. Four of these seem referable to Turbonilla (Turbonilla) or a closely related taxon. Turbonilla (Strioturbonilla) theona Bartsch In Dall, 1927, and T. (Strioturbonilla) pyrrha Bartsch In Dall, 1927 (non Bush, 1899), are sufficiently well characterized to assure subgeneric recognition and neither is present in the mudlump fauna.

Two other species present graver problems. These are Turbonilla virga Dall (1884, p. 332) and T. punicea Dall (1884, p. 332). Neither has been illustrated and neither is sufficiently well characterized to permit recognition. Still, enough data are given to assure distinction from mudlump species.

Turbonilla (Turbonilla) uncina Corgan, new species

Plate XII, Figures 7, 12

Description.- Turbonilla (Turbonilla) of high spired growth form; whorls vary from flat-sided to inflated, suture from slightly to deeply incised; axial sculpture of prominent, opisthocline ribs that are occasionally sinuous; ribs vary from narrower to wider than interspaces; number of ribs varies from about 18 to 30 on the fourth postprotoconch whorl; ribs sometimes becoming obsolete, obsolescence generally beginning on third whorl; individual specimens are ornate to varying degrees and remain similarly ornate throughout ontogeny; axial ribs generally sharply delimited at periphery, sometimes gradually disappearing at periphery, extending over base when sculpture becomes obsolescent; protoconch varies from about 2.5 to about 3.5 whorls, high spired, appears loosely coiled, varying from about .25 to .42 mm in diameter, uniformly about one-third immersed and at about 90° to adult axis; reaching about 4.5 volutions at an apparent maximum, maximum observed size about 1.92 mm in length and .72 mm in width, normally about 1.60 mm in length and .58 mm in width at about 4.5 whorls.

Comparisons.- The deterioration of sculpture in large specimens of Turbonilla uncina is believed to be an indication of adulthood. The approach to a limiting number of whorls is also evidence that mudlump species are adult. Apparently Turbonilla (Turbonilla) uncina Corgan is one of the smallest species of Turbonilla.

Only one Western Atlantic species bears a marked resemblance to T. uncina. This is Turbonilla (Nisiturris) pupapicula Weisbord, described from the Miocene ? of Venezuela (Weisbord, 1962, p. 473, pl. 45, figs. 2-3, pl. 46, figs. 1-2). Weisbord's species appears to be known only from juveniles. It definitely belongs to the same superspecific group as T. uncina but it seems more acicular and has fewer ribs. Further, in T. pupapicula, ribs seem to gradually lessen at the periphery and spiral sculpture is present.

Remarks.- Mudlump populations show a fairly high incidence of predation. This suggests that T. uncina is a vagrant form.

Derivation of Name.- From the Latin uncina, hooked, in allusion to the hook like appearance of the large protoconch extending over the small shell.

Occurrence and Abundance.- PAL 7 (38)

Holotype.- LSUDGMTC 7443.

Figured Specimen.- LSUDGMTC 7443-7444.

Turbonilla (Turbonilla) conferta Corgan, new species

Plate XII, Figures 1, 5, 11

Description.- Turbonilla (Turbonilla) of moderately high spired growth form; whorls flat sided, suture moderately incised and sometimes

channeled, whorl profile slightly tabulated, pronounced tabulation in specimens with a channeled suture; protoconch at 90° to adult axis, more or less high spired, appearing globular when worn, height and width about equal, 2.5 to 3 whorls; protoconch very variable in size and a small protoconch appears to lead to a small teleoconch, a large protoconch to a large teleoconch; protoconch from about .15 x .15 mm to .31 x .31 mm; spiral sculpture frequently absent, generally present in specimens of large proportions; spiral sculpture very fine, sometimes extending across axial ribs, generally restricted to intercostal spaces, always restricted to spire; axial ribs restricted to spire in juveniles, extending onto base in adults; adults may show a pile up of axial ribs that are interpretable as a major growth stop; about 18 to 22 axial ribs on initial teleoconch whorl; about 24 to 27 on fourth teleoconch whorl; ribs almost orthocline, about as wide as interspaces; columella with slight ridge, without external tooth; inner lip slightly reflexed, sometimes forming a chink-like pseudoumbilicus; size at 4 to 4.5 whorls generally about 1.68 mm in length and .62 mm in width, reaching an extreme of about 2.08 mm in length and .80 mm in width.

Comparisons.- The species is very variable, but the protoconch type and general growth form remain fairly constant. Turbonilla conferta has fewer whorls than any West American species described by Dall and Bartsch (1909). It also appears to have fewer whorls than any Western Atlantic species known from the adult. The change in persistence of axial sculpture and reflection of the inner lip both suggest that T. conferta is truly adult at about 4 whorls. Presence

of specimens near this limit in three mudlump collections also suggests this is the maximum whorl number.

The species most similar to T. conferta is T. uncina Corgan, described above. The flattish whorl profile of T. conferta and the dense, even axial sculpture are distinguishing characters.

Remarks.- A snail boring in the specimen from SP 5 suggests this is a free living species.

Derivation of Name.- From the Latin conferta, crowded, in allusion to the abundant axial sculpture.

Occurrence and Abundance.- PAL 7 (9); SP 5 (1); SP 6 (2).

Holotype.- LSUDGMTC 7420.

Figured Specimens.- LSUDGMTC 7418-7420.

Turbonilla (Turbonilla) heathae Corgan, new species

Plate XII, Figure 6

Description.- Turbonilla (Turbonilla)of high spired growth form, whorls flat-sided, suture appressed and regular; without spiral sculpture; axial ribs wider than interspaces, flat topped, about 23 ribs on fourth post-protoconch whorl; protoconch slightly elevated, about one-third immersed, height and width equal, about .26 by .26 mm; size at 4 whorls about 1.49 by .54 mm.

Comparisons.- In protoconch proportions, number of ribs, and size at 4 whorls, Turbonilla heathae Corgan, is quite comparable to T. conferta Corgan, described above. The ribs of T. heathae are relatively broader and flatter. Further, this species appears more elongate.

Remarks.- The holotype and only known specimen of T. heathae may not be fully adult but all essential features of the adult appear well developed.

Derivation of Name.- In honor of my typist, Mrs. Joan Heath.

Occurrence and Abundance.- PAL 7 (1).

Holotype.- LSUDGMTC 7402.

Turbonilla (Turbonilla) flexio Corgan, new species

Plate X, Figure 10-11

Description.- Turbonilla (Turbonilla) of high spired growth form; protoconch high spired, loosely coiled, slightly over three whorls, about one-fourth immersed, roughly .19 x .23 mm; whorls flat sided, slightly tabulated; suture incised, fairly smooth, axial ribs not rising above whorl profile; adult without spiral sculpture, juvenile occasionally with dense cover of microscopic spiral striations; axial sculpture

generally restricted to spire, with occasional ribs persisting onto base in adults; axial ribs prominent, highly elevated, generally much narrower than interspaces, varying from opisthocline to opisthocyrt, generally opisthocyrt on some part of later whorls, from 15 to 19 ribs on specimens with 5 or more whorls; columella with slight flexure, without external tooth; adult reaching about 10 post-protoconch whorls; size at 7.5 post-protoconch whorls 2.54 mm in length and .68 mm in width.

Comparison.- If Chemnitzia were recognized as a valid taxon, Turbonilla flexio would be referred to it. No described Western Atlantic or Eastern Pacific species is comparable and T. flexio appears to have no close analogue anywhere. Similarity of protoconch character suggests a relationship with Turbonilla uncina Corgan, new species, described above. Further, some T. uncina have curved ribs but the two species differ greatly in size and growth form.

Remarks.- Two specimens of T. flexio show snail borings. This suggests the species is vagrant.

Derivation of Name.- From the Latin flexio, bend, in allusion to the opisthocyrt ribs.

Occurrence and Abundance.- SP 1-B -350.9 to 351.1 (1); SP 6 (11).

Holotype.-

Figured Specimen.-

Turbonilla (Turbonilla) procera Corgan, new species

Plate XI, Figures 3, 4, 9

Description.- Turbonilla (Turbonilla) of elongate growth form, with slight volume increase per whorl; whorls flat-sided, suture appressed to incised; axial macrosculpture of 14 to 17 sharply elevated, slightly opisthocline axial ribs which extend above the whorl profile; occasionally with faint axial microsculpture of incised lines; interspaces wider than macroribs; without spiral sculpture; axial sculpture generally abruptly terminated at periphery, occasionally becoming obsolete; protoconch moderately high spired, coiled at 90° to adult axis, largest about .30 mm high and .25 mm wide, about 3 whorls; without parietal tooth or columellar plication; size at 10 whorls length 3.68 mm, height .80 mm; reaching about 13 whorls with length approximately 5.30 mm and diameter .96 mm.

Comparisons.- The Oligocene T. cercadensis Maury, 1917, is most similar, but it has ribs wider than the interspaces.

Derivation of Name.- From the Latin procera, tall, in allusion to the elongate growth form.

Occurrence and Abundance.- PAL 7 (47); SP 5 (1); SP 6 (2).

Holotype.- LSUDGMTC 7413.

Figured Specimen.- LSUDGMTC 7410, 7413, 7414.

Turbonilla (Turbonilla) fustis Corgan, new species

Plate XI, Figures 2, 7

Description.- Turbonilla (Turbonilla) with protoconch very high spired, at about 90° to adult axis, one-fourth immersed, initial chamber very small, rapidly expanding, reaching about .38 by .42 mm; teleoconch high spired, whorl profile inflated with inflation most pronounced on anterior half of whorl; sculpture of axial ribs only, restricted to spire; about 15 axial ribs on first teleoconch volution and about 17 on fifth; size 2.30 mm in length and .76 mm in width.

Comparisons.- Turbonilla (Turbonilla) fustis Corgan, new species, is strongly convergent with Turbonilla (Turbonilla) confinium Corgan, described below. They differ greatly in protoconch character. Turbonilla confinium is known from large populations and always has an extremely low spired protoconch. The protoconch of T. fustis is very high spired. Most T. confinium have obvious spiral microsculpture and there is no spiral sculpture in the holotype and only known specimen of T. fustis.

Remarks.- A snail boring suggests that T. fustis is a free-living species.

Derivation of Name.- From the Latin fustis, a club, in allusion to the inflated whorl profile of this elongate species.

Occurrence and Abundance.- SP 6 (6)

Holotype.- LSUDGMTC 7398.

Figured Specimens.- LSUDGMTC 7398, 7445.

Turbonilla (Turbonilla) asperella Corgan, new species

Plate XII, Figure 10

Description.- Turbonilla (Turbonilla) of high spired growth form; whorl profile asymmetrically inflated with maximum inflation on anterior half; suture closely appressed; protoconch very low spired, asymmetrical, about 2.5 volutions, .38 x .30 mm; teleoconch with abundant incised spiral lines on both spire and base; axial sculpture of prominent ribs that are best developed on spire but extend faintly over the entire base, 17 ribs at 4 volutions, 23 at 8 volutions; size at 8.5 whorls 4.46 mm in length and 1.12 mm in width.

Comparisons.- This species strongly resembles T. confinium described below but it is much broader and significantly larger.

Remarks.- The protoconch of T. asperella is quite similar to that of some Turbonilla (Pyrgiscus), for example Turbonilla (Pyrgiscus) ellisi.

Derivation of Name.- A diminutive from the Latin asper, round, in allusion to the rounded, inflated whorl profile.

Occurrence and Abundance.- SP 6 (1).

Holotype.- LSUDGMTC 7393.

Turbonilla (Turbonilla) confinium Corgan, new species

Plate XI, Figure 6

Description.- Turbonilla (Turbonilla) with protoconch very low spired, coiled at about 90° to adult axis, one-fourth immersed, about 3 whorls; adult reaching 8.5 or more whorls; whorl profile variable, gently rounded to slightly inflated with maximum inflation on the anterior third; axial sculpture of slightly rounded, sharply elevated, slightly prosocline ribs which number from 13 to 16 on the body whorl; ribs generally terminate abruptly at the periphery, occasionally with a few ribs persisting onto the base; spiral sculpture of equally spaced, minute, incised lines, about 28 on the spire of body whorl; spiral sculpture occasionally not apparent in worn specimens; base generally without axial sculpture, with incised spiral lines; aperture subquadrate, outer lip thin, inner lip thickened, reflected along the columellar margin; size at 8.5 volutions generally about 4.1 mm in length and .5 mm in width.

Comparisons.- In the nomenclature most frequently used, T. confinium would be a Turbonilla (Chemnitzia) or possibly a Turbonilla (Strioturbonilla). It is more elongate than T. (Strioturbonilla) pyrrha Bartsch (non Bush). Chemnitzia turris Orbigny, 1841, is similar but more ornate. A comparison is made with T. fustis Corgan in the description of that species, above.

Remarks.- Snail borings suggest T. confinium is a vagrant form.

Derivation of Name.- From the Latin confinium, border, in allusion to the bordered appearance caused by the abrupt termination of most or all axial ribs.

Occurrence and Abundance.- PAL 7 (26), SP 1-B -455.75 to 455.95 (1); SP 6 (2).

Holotype.- LSUDGMTC 7406.

Figured Specimen.- LSUDGMTC 7406.

Turbonilla (Turbonilla) erwini Corgan, new species

Plate XI, Figure 1

Description.- Turbonilla (Turbonilla) of high spired growth form, suture appressed, whorls flat sided on early whorls becoming slightly rounded later; shell very heavy, sturdily built; sculpture of axial ribs and spiral lines; spiral sculpture dense on spire, weakly developed on base; axial ribs narrower than interspaces, terminating at periphery, about 16 ribs at 5.7 whorls; columella distinctly flexed, aperture broken in only specimen, apparently with weak tooth on columellar margin of inner lip; protoconch very low spired, globular, about 2.5 whorls, at 90° to adult axis, about .32 x .26 mm; size at 5.7 whorls 2.17 mm in length and .68 mm in width.

Comparisons.- The thick shell and heavy appearance of this slender Turbonilla make it quite distinct from all described North American forms. In protoconch character it resembles T. confinium, described above.

Remarks.- A snail boring suggests this is a vagrant species.

Derivation of Name.- In honor of Erwin K. Krause, Sinclair micropaleontologist and coauthor of a standard monograph of Gulf Coast Eocene mollusks.

Occurrence and Abundance.- SP 6 (1).

Holotype.- LSUDGMTC 7358.

Turbonilla (Turbonilla) apiculata Corgan, new species

Plate XII, Figure 8

Description.- Turbonilla (Turbonilla) of high spired growth form; suture incised; whorl more or less flat-sided; protoconch at about 90° to adult axis, flat spired, about 2.5 volutions, size about .32 by .26 mm; adult with prominent and equal axial ribs and faint spiral striations; spiral sculpture restricted to intercostal areas on spire; axial ribs ranging from markedly opisthocline to nearly orthocline; axial ribs of juvenile more or less limited to spire, extending over base on last half volution; ribs about as broad as

interspaces; about 19 axial ribs on body whorl; columella with a low ridge; columellar margin of inner lip with a weak tooth; reaching about 5.5 post-protoconch volutions, size maximum about 2.24 mm in length and .70 mm in width.

Comparisons.- Though it is a rather typical Turbonilla, T. (Turbonilla) apiculata seems quite distinct from all Western Atlantic and Eastern Pacific forms. It is best compared to T. confinium Corgan, new species, described above. Turbonilla apiculata is much smaller than T. confinium and has more axial ribs.

Remarks.- Snail borings suggest a vagrant mode of life.

Derivation of Name.- From the Latin apiculata, in the sense of bearing a point, in allusion to the point-like appearance of the protoconch.

Occurrence and Abundance.- SP 6 (5).

Holotype.- LSUDGMTC 7437.

Figured Specimen.- LSUDGMTC 7437.

Turbonilla (Turbonilla) baca Corgan, new species

Plate XI, Figure 8

Description.- Turbonilla (Turbonilla) of extremely elongate growth form; slowly expanding; whorl flat-sided; suture incised; axial sculpture of sharply elevated, slightly opisthocline ribs, 16 to 18 at

about 9 post-protoconch whorls; interspaces wider than ribs; axial ribs terminate at periphery; without spiral microsculpture; protoconch globular, coiled at 90° to adult axis; one-fourth immersed, two or three whorls; with low columellar plication and weakly differentiated tooth on columellar margin; size at about 9.5 whorls, 3.00 mm in length and .60 mm in width.

Comparisons.- Turbonilla (Turbonilla) baca Corgan resembles T. calva Corgan and T. procera Corgan, both described above. In T. calva and T. procera the protoconch is high spired and the columella lacks a plication. The protoconch is very low spired and the columella plicate in T. baca.

In the terminology of Bartsch (1955), T. baca would be a Turbonilla (Chemnitzia).

Derivation of Name.- From the Latin baca, a berry, in allusion to the fruit-like appearance of the small, globular protoconch.

Occurrence and Abundance.- PAL 7 (2).

Holotype.- LSUDGMTC 7367.

Figured Specimen.- LSUDGMTC 7367.

TURBONILLA (PYRGISCUS) Philippi

1841. Pyrgiscus PHILIPPI, Wiegm, Arch. f. Natur., v. 1, p. 50.

1843. Orthostelis ARADAS AND MAGGIORE, Atti Accad. Giov. Catania, v. 20, p. 118 (objective synonym).

1884. Pyrgostelis MONTEROSATO, Nomen. Gen. Spec., p. 84 (objective synonym).

1937. Pyrgiscilla LAWS, Trans. Proc. Roy. Soc. New Zealand, v. 67, p. 172 [Type species by original designation, Turbonilla (Strioturbonilla) chattonensis Marwick].

Type Species.- By subsequent designation, Dall and Bartsch 1903, Melania rufa Philippi.

Diagnosis.- Turbonilla with rounded axial ribs and spiral ribs or incised spiral lines; axials generally most prominent; elements of spiral sculpture generally subequal; whorl profile flat; shoulder not generally tabulated; without internal lirations on outer lip.

Comparisons.- Pyrgiscus differs from Turbonilla s.s. in the greater development of spiral sculpture. Attempts have been made to subdivide Pyrgiscus on the basis of persistence of axial sculpture (e.g.: Laws, 1937b) but this does not seem tenable. Some Pyrgiscus have spiral ribs, rather than incised lines but this does not seem to reflect a fundamental difference. A few species [e.g.: Turbonilla (Pyrgiscus) wilberti Corgan, described below] show a change from spiral ribs on the spire to spiral lines on the base.

Most modern authors treat Pyrgiscus as a full genus; however, species transitional between Pyrgiscus and Turbonilla are fairly common and subgeneric distinction more clearly conveys the apparent relationship.

Remarks.- Discussion of Western Atlantic Turbonilla (Pyrgiscus) requires evaluation of four unillustrated species.

The very broad ribs of Turbonilla (Pyrgiscus) conoma Bartsch In Dall, 1927, distinguish it from mudlump species. Turbonilla (Pyrgiscus) miona Bartsch In Dall, 1927, also has broad ribs. In addition, it has a parietal fold, a tooth on the columellar margin of the inner lip, and a rather small number of incised spiral lines. Collectively, these make this species distinct from mudlump taxa.

According to Clench and Turner (1950, p. 337), the type of Chemnitzia reticulata C. B. Adams, 1850, is lost. It appears to be a Turbonilla (Pyrgiscus) and has never been illustrated. From the original descriptions, it is quite ornate, with 26-30 axial ribs. The spiral sculpture is widely spaced. Axials become obsolete on the base and the whorl profile is inflated. These characters seem to distinguish T. reticulata (C. B. Adams) from mudlump species.

Dall (1892, p. 260) placed Turbonilla caroliniana Holmes in the synonymy of Chemnitzia reticulata Adams and described a new variety, Turbonilla reticulata cingulata Dall, which has "one of the spiral threads behind the middle of the whorl swollen more than the others, as in Holmes' T. speira, which gives a shouldered aspect to the whorls, but this is an exceptional mutation" (Dall, 1892, p. 260).

Holmes' species, if the drawing is anywhere near accurate

(Holmes, 1859, p. 86, pl. 13, fig. 7-7b), has far fewer ribs than Chemnitzia reticulata C. B. Adams. Further Adams (1850a, p. 75) described his species as having an impressed suture and a scarcely thickened labrum. Holmes' species differs in each of these characters. Clearly, Chemnitzia reticulata C. B. Adams and Turbonilla caroliniana Holmes are not synonymous. This leaves Dall's concept of Turbonilla reticulata in doubt and makes his description of T. reticulata cingulata most difficult to recognize. It does not seem to be represented in the mudlump fauna but its specific characters are unclear.

In the terminology of Dall and Bartsch (1904) Dall's Turbonilla cingulata is a junior homonym of Turbonilla (Cingulina) cingulata (Dunker) (Dall and Bartsch, 1909, p. 12). The two are not here believed congeneric.

Turbonilla (Pyrgiscus) norae Corgan, new species

Plate XIII, Figures 2,4

Description.- Turbonilla (Pyrgiscus) of high spired growth form; axial sculpture of prominent, well-defined ribs that are narrower than interspaces, axials faint on base or becoming obsolete at periphery, about 22 axials on body whorl, 18 on early whorls; spiral sculpture very variable, faint axial ribs in intercostal spaces that sometimes extend over ribs and sometimes become incised lines on base, from 10 to 18 spirals on seventh post-protoconch whorl, from 0 to 12 on base; suture more deeply incised in juvenile than in

adult, sometimes crenulated by axial ribs; initial teleoconch whorls loosely coiled, becoming tightly coiled in adult; protoconch varying from totally emergent to slightly immersed, globular or very low spired, maximum observed size .26 x .22 mm; adult size to 3.84 mm in length and 1.10 mm in width at 7.3 whorls.

Comparisons.- An emergent to slightly immersed protoconch and loose juvenile coiling are the most unusual features of this very distinctive species.

Some specimens illustrated by Bush (1909) as Turbonilla interrupta (Totten) have rather similar protoconch but differ in teleoconch sculpture. The protoconch is reminiscent of the Pacific genus Koloonella Laseron (1959, p. 246), but all Koloonella have extremely simple adult sculpture.

Though variable, the spiral ribs of T. norae are similar to those of Turbonilla palmerae Aguayo and Jaume (1936, p. 119, figs. 1-3). Adult sizes are comparable but T. palmerae is tightly coiled throughout ontogeny and the axial ribs are broad and flat.

Remarks.- The teleoconch of T. norae is rather typical of Turbonilla (Pyrgiscus) and this suggests that the everted or slightly immersed protoconch is not a pathologic character. Snail borings suggest the species is free living.

Derivation of Name.- In honor of my mother, Mrs. Nora Corgan, who made many contributions to this dissertation.

Occurrence and Abundance.- SP 6 (1), PAL 7 (1).

Holotype.- LSUDGMTC 7403.

Figured Specimens.- LSUDGMTC 7403, 7433.

Turbonilla (Pyrgiscus) ellisi Corgan, new species

Plate XII, Figure 4

Description.- Turbonilla (Pyrgiscus) of slender, high spired growth form; suture incised, fairly regular, shoulder not tabulated; axial sculpture dominant; axial sculpture of prominent, slightly opisthocline ribs that become obsolete just below the periphery; spiral sculpture of subequal, faint incised lines that do not cross axial ribs; base spirally incised; about 20 axial ribs on the seventh post-protoconch whorl, 16 on the second; about 18 spiral lines on the penultimate whorl, 17 on the second; base with about 7 spiral lines; columella with faint plication; without externally apparent tooth; protoconch slightly over 2 whorls, large, low spired, globular nucleus very small, asymmetrically placed, protoconch size about .28 mm in maximum diameter; size at 7 post-protoconch whorls 3.14 mm in length, .72 mm in width.

Comparisons.- Growth form, sculpture, and protoconch character readily distinguish Turbonilla (Pyrgiscus) ellisi Corgan, new species, from all Western Atlantic forms. Turbonilla (Pyrgiscus) dominicensis Gabb,

as illustrated by Pilsbry (1922, p. 391, pl. 36, fig. 3) has the sculpture change from opisthocline in the juvenile to prosocline in the adult. Maury's illustration of the same species (Maury, 1917, p. 148, pl. 25, fig. 14) shows it opisthocline throughout. Maury's illustration shows a shell quite comparable to T. ellisi. This Oligocene species from Santo Domingo has far fewer ribs and is broader than T. ellisi.

Remarks.- The paratype of T. ellisi has about 5.5 whorls and lacks basal sculpture. This may be a result of breakage but it is possible that basal spirals develop only in the adult.

A snail boring in the holotype suggests that this species does not live within a host.

Derivation of Name.- In honor of Dr. Charles W. Ellis, leader of the environmental analysis group in the Sinclair Research Laboratory.

Occurrence and Abundance.- PAL 7 (2).

Holotype.- LSUDGMTC 7400.

Figured Specimen.- LSUDGMTC 7400.

Turbonilla (Pyrgiscus) olus Corgan, new species

Plate XII, Figure 2

Description.- Turbonilla (Pyrgiscus) of elongate growth form; whorl profile inflated, greatest diameter low on anterior third of whorls; axial sculpture dominant; spiral sculpture very variable, with or

without very faint spiral sculpture on mid-whorl and base, with one or two sharply elevated threads below suture, with about three sharply elevated spiral threads low on spire; with about 16 well defined axial ribs on early whorls, 18-20 on body whorl; axial ribs about equal to interspaces, ending at the base of the spire; with or without a small, chink-like umbilicus; with a fairly strong columellar plication that is generally expressed as a low tooth on the columellar margin of the inner lip; axis of protoconch coiling varies through about 45°, generally at about 110° to adult axis; protoconch low spired, with a large, round initial whorl, generally about .22 mm wide and .18 mm high; adult reaching 6.5 whorls, generally about 4.5 to 5.5 whorls; apical whorls appear thickened in the late adult; maximum size about 1.88 mm in length and .58 mm in width, generally about 1.58 mm long, .51 mm wide.

Comparisons.- No described pyramidellid bears a close resemblance to Turbonilla (Pyrgiscus) olus Corgan, new species. Presence of a fairly well developed tooth suggests an affinity with the odostomid stock and in the classification of Dall and Bartsch (1909) it would probably be referred to Salassia or a similar genus.

Still, the protoconch and all elements of ornamentation are the same as more typical Pyrgiscus and strong columellar plications occasionally develop in this stock. Sorgenfrei (1958) described a number of European species that resemble T. olus in gross sculptural pattern. He placed them in Chrysallida. Several of these, like C. toftlundensis Sorgenfrei, have a restricted distribution of coarse

spiral sculpture but all have immersed protoconchs.

Derivation of Name.- From the Latin olus, turnip, in allusion to the inflated whorl profile.

Occurrence and Abundance.- SP 6 (10); PAL 7 (4).

Holotype.- LSUDGMTC 7432.

Figured Specimen.- LSUDGMTC 7432.

Turbonilla (Pyrgiscus) buskirkae Corgan, new species

Plate XII, Figures 9, 13

Description.- Turbonilla (Pyrgiscus) of broad, high spired growth form; suture and shoulder variable, closely appressed to faintly tabulated; axial ribs on spire persist as faint rays on base, roughly aligned on succeeding whorls, number constant at about 19 in later adult, except in areas of varix-like growth stops; spiral ribs variable, about 7 on spire of adult, subequal, some individuals with faint thread, others with broad ribs, some individuals with a pale yellow band containing the second spiral above the suture; later adult with faint, numerous microscopic striations; base with about 7 spirals; protoconch low spired, about one third immersed, from .24 to .33 mm wide, about two-thirds as high; reaching at least 6.5 whorls and 3.5 mm in length at 1.10 mm in width.

Comparison.- Both known specimens of T. buskirkae are illustrated in Plate XII. At first glance, they seem specifically distinct. Spiral sculpture, protoconch size, and insertion of the protoconch differ. Number of ribs, elements of sculpture, protoconch proportions, columellar plication, growth form, size at 4 whorls, and rate of whorl expansion are virtually identical.

Mormula harrisi Bartsch (1955, p. 32, pl. 5, figs. 1-1a) is the most comparable described species. It has a far greater abundance of coarser, more equal, spiral ribs. Use of Mormula A. Adams in Bartsch (1955) is discussed under Turbonilla rolfei.

Derivation of Name.- In honor of Miss Dorothy Van Buskirk, who aided with clerical matters in the preparation of this dissertation.

Occurrence and Abundance.- SP 6 (1), SP 5 (1).

Holotype.- LSUDGMTC 7401.

Figured Specimens.- LSUDGMTC 7401, 7369.

Turbonilla (Pyrgiscus) tabulatella Corgan, new species

Plate XIII, Figure 3

Description.- Turbonilla (Pyrgiscus) of high spired, tabulated growth

form; protoconch very low spired, slightly over 2 whorls, about one-third immersed, at from 90° to 110° to adult coiling axis, about .30 x .24 mm; whorls flat-sided, suture incised, axial sculpture not rising above whorls profile; axial sculpture dominant; axial ribs prominent, generally limited to spire, rarely with a few ribs extending onto base in large specimens; axial ribs generally nearly orthocline, occasionally slightly prosocline or, more rarely, opisthocline; axial ribs always sharply elevated, occasionally produced into blade-like ridges, ridges or blades frequently inflated in the sutural region; between 16 and 20 axial ribs at 4.5 whorls; spiral sculpture of elevated ribs that are restricted to intercostal areas on the spire; spiral sculpture extremely variable, between 4 and 9 spiral ribs on the spire, the sub-sutural rib generally more pronounced, sometimes equal to others; with 1 or more generally 2 spirals at the periphery that are more pronounced than the 8 to 11 other spirals of the base; inner lip generally reflected to form a chink-like pseudoumbilicus; columella not notably flexed, inner lip without tooth; peristome complete; well preserved specimens show an orange band at mid-whorl; at 4.5 whorls, specimens vary from 2.24 mm in length and .94 mm in width to 1.83 mm in length and .88 mm in width.

Comparisons.- This species is quite dissimilar from described forms. It is best compared to Turbonilla buskirkae Corgan, described above. Both species have a color band on mid-whorl, protoconch characters are similar, and sizes are comparable. Turbonilla buskirkae lacks the peripheral sculpture of T. tabulatella, has a less tabulate growth form, and has a clearly developed columellar flexure.

Remarks.- Occasional snail borings suggest T. tabulatella is free living.

Derivation of Name.- From the Latin tabulatum, floor, story, level, etc., in allusion to the tabulate appearance of this little shell.

Occurrence and Abundance.- SP 5 (1); SP 6 (19).

Holotype.-

Figured Specimens.-

Turbonilla (Pyrgiscus) chenowethi Corgan, new species

Plate XII, Figure 3

Description.- Turbonilla (Pyrgiscus) of elongate growth form; whorls faintly tabulate; protoconch very low spired, coiled at about 110° to adult axis, symmetrical; a bit over 2 whorls, about one-third immersed; axial sculpture much more prominent than spiral; axial ribs extending over most of the base; spiral sculpture similar on spire and base; spiral sculpture of subequal, slightly elevated threads; second subsutural thread largest, about 3 times average; about 8 spiral threads on early whorls 12 on penultimate; axial ribs slightly narrower than interspaces, not incised by spirals; about 15 axial ribs on early whorls, about 18 on body whorl; peristome apparently complete, thin in parietal area; basal profile smoothly rounded, without a distinct periphery; columella with faint plication; unbroken specimens probably

have a minute tooth on the columellar margin of the inner lip; size at 6.5 whorls, 2.4 mm in length and .66 mm in width.

Comparisons.- The only known specimen of Turbonilla chenowethi shows a combination of features not previously reported in the Western Atlantic fauna. Few Western Atlantic species have continuous ribs and most of these are known only as fossils. Turbonilla (Pyrgiscus) santodomingensis Pilsbry and Johnson (1917, p. 175) seems most comparable but it lacks the tabulated whorls and is more acicular. Pilsbry (1922, p. 391, pl. 36, fig. 4) illustrates this species.

Remarks.- A snail boring suggests T. chenowethi is free living.

Derivation of Name.- In honor of Dr. Philip A. Chenoweth, Sinclair Oil & Gas Company, a leading authority on the geology of the mid-continent and a reviewer of this report.

Occurrence and Abundance.- PAL 7 (1).

Holotype.- LSUDGMTC 7405.

Turbonilla (Pyrgiscus) butlerae Corgan, new species

Plate XI, Figure 5

Description.- Turbonilla (Pyrgiscus) of elongate-pupoidal growth form; whorls slightly tabulate; protoconch very low spired, coiled at about 110° to adult axis, symmetrical, about 2 whorls, one-third immersed;

protoconch about .25 mm wide and .14 mm high; axial sculpture much stronger than spiral; axial ribs prominent, wider than interspaces, inflated near suture, extending above whorl profile; number of ribs appears constant throughout ontogeny, about 15 per whorl; axial ribs becoming obsolescent near periphery, base unornamented; spiral sculpture faint, more or less equally developed, incised spiral lines, about 17 on fifth whorl, about 12 on spire of third whorl, not evident on early whorls; aperture broken, without pronounced ridge on columella; size of holotype, at 5.5 whorls, 1.92 mm in length and .63 mm in width.

Comparisons.- Turbonilla (Pyrgiscus) butlerae Corgan, new species, is most comparable to Turbonilla (Pyrgiscus) chenowethi Corgan, described above. It differs in having the axial ribs limited to the spire and the far lesser development of spiral sculpture.

Remarks.- Though known from a single specimen, T. butlerae is a most distinctive species. Abundant snail borings in the holotype suggest the species is free living.

Derivation of Name.- In honor of Mrs. E. Ann Butler, Sinclair Oil & Gas Company, a leading Gulf Coast micropaleontologist.

Occurrence and Abundance.- PAL 7 (1).

Holotype.- LSUDGMTC 7404.

Turbonilla (Pyrgiscus) rolfei Corgan, new species

Plate XIII, Figure 1

Description.- Turbonilla (Pyrgiscus) of broad, high spired growth form; axial sculpture much stronger than spiral; axial sculpture of prominent ribs that are narrower than or equal to interspaces; ribs become obsolete, extending across about one-third of the base; with 18 - 22 ribs on the ninth post-protoconch whorl and 14 - 15 ribs on the early teleoconch whorls; spiral sculpture of incised lines, about every other line deeper, peripheral lines emphasized, about as broad as interspaces; about 14 lines exposed on earliest whorls, about 22 on penultimate whorl; spiral sculpture weakly developed on the axially sculptured portion of the base, lost before axial ribs disappear; spiral lines restricted to intercostal spaces, not apparent on axial ribs; suture closely appressed, made crenelate by continuance of axial ribbing; protoconch unknown; columellar plication developed; with a weak tooth on the columellar margin of the inner lip; size of largest known specimen 6.24 mm in length and .88 mm in width in a broken specimen with 8.3 post-protoconch whorls preserved, the protoconch and first teleoconch whorl missing; size at 10 whorls about 6.5 mm.

Comparison.- When the number of whorls is considered, Turbonilla rolfei Corgan, new species, is far larger than most Western Atlantic Turbonilla. The most comparable species is the gigantic Turbonilla louiseae Clarke (1954, p. 118, pl. 9). This species has a more impressed suture, has axial sculpture incised by spiral, and is half-again as large.

In standard works, species resembling T. rolfei have been referred to Turbonilla (Pyrgolampros) and to the genus Mormula A. Adams 1863, which is sometimes treated as a subgenus of Turbonilla. From A. Adams (1863), Melvill and Sykes (1897), and Melvill (1910), it appears that significant varices, internal lirations, a Rissoina-like growth form, and an Odostomia-like parietal tooth are significant characters of Mormula. A species with these characters has yet to be reported from the Western Atlantic, though Mormula has a large nominal content from this region.

Derivation of Name.- In honor of Dr. B N. Rolfe, director of geologic research, Sinclair Oil & Gas Company.

Occurrence and Abundance.- PAL 7 (2).

Holotype.- LSUDGMTC 7370.

Figured Specimen.- LSUDGMTC 7370.

Turbonilla (Pyrgiscus) wilberti Corgan, new species

Plate XIII, Figure 5

Description.- Turbonilla (Pyrgiscus) of sturdy build, shell relatively thick; suture incised; axial sculpture stronger than spiral; axial ribs becoming less prominent on base, disappearing except in the apertural region; spiral sculpture changes from ribs on the spire to impressed lines on the base; about 14 spiral ribs on spire throughout ontogeny,

about 7 spiral lines on base of body whorl; axial ribs well defined, much narrower than interspaces, about 31 - 32 on body whorl with 2 or 3 zones of crowded ribbing on body whorl that appear to represent varices; with 19 or fewer axial ribs on early whorls and occasional varices throughout teleoconch; peristome incomplete; without columellar plication; aperture elliptical; maximum size and protoconch unknown, reaching at least 4.5 mm, 4.06 mm in length and 1.04 mm in width with 7.5 whorls preserved, perfect specimens probably about 10 whorls.

Comparison.- The change from spiral ribs on the spire to incised spiral lines on the base is fairly unusual. The growth form is also distinctive. Superficially, it resembles Turbonilla (Pyrgiscus) palmerae Aguayo and Jaume (1936, p. 119, figs. 1-3). This common Cuban species is less ornate, large, and has incised spiral sculpture on the spire.

Derivation of Name.- In honor of Dr. Louis Wilbert, deceased, a former Professor of Paleontology at Louisiana State University and collector of samples from PAL 7.

Occurrence and Abundance.- PAL 7 (2).

Holotype.- LSUDGMTC 7394.

Figured Specimen.- LSUDGMTC 7394.

Subfamily ODOSTOMIINAE Locard, 1886

1886. Ptychostomidae LOCARD, Prodr. Malac. Franc., Mol. Mar., v. 2, p. 228.

Diagnosis.- Pyramidellids of bulbous to moderately high spired growth form; with a single columellar plication and, generally, with a parietal tooth; protoconch almost always heterostrophic; shell delicate to sturdy; frequently without sculpture, never ornate; generally with a few rapidly expanding whorls; protoconch generally immersed; size minute to moderately large.

Remarks.- Authorship of pyramidellacean family-level taxa is never stated in the literature. Ptychostomon Locard, 1886, is an objective junior synonym of Odostomia Flemming, 1813, and was used as the basis for a familial name when first introduced. It is possible that Locard's familial name is antedated by one or more familial level terms based on Odostomia, a subjective or objective synonym, or a confamilial generic term. Still, this was not suggested by dissertation research.

Genus EULIMASTOMA Bartsch, 1916

1916. Eulimastoma BARTSCH, Nautilus, v. 30, p. 73.

1951. Telloda HERTLEIN AND STRONG, Zoologica, v. 36, p. 104 (Type species, by original designation, Odostomia (Scalenostoma) dotella Dall and Bartsch).

Type Species.- By original designation, Odostomia (Scalenostoma) dotella Dall and Bartsch.

Diagnosis.- Odostomiinae with a pronounced angulation at the whorl base; without other prominent sculpture; relatively high spired; whorls flat sided; with or without umbilicus; heterostrophic; size minute to moderately large.

Eulimastoma vetula Corgan, new species

Plate IV, Figure 3; Plate X, Figures 5-6

Description.- Eulimastoma of small size, peripheral angulation always distinct, variable, sometimes produced into small keel; without other sculpture; umbilicus poorly developed to well developed in juveniles, becoming closed in adult; shell thin in region of growth, spire becoming greatly thickened; tooth low, rounded; columellar plication very strong; aperture elliptical, modified by peripheral keel; base smoothly sloping to aperture; protoconch completely immersed, coiling not apparent; with an observed maximum of 4 whorls along the adult axis; size at 4 whorls from 1.24 to 1.38 mm, width about .70 mm.

Remarks.- Bartsch (1955, p. 82-83) described two species of Eulimastoma from the Pliocene of St. Petersburg, Florida: E. harbisonae and E. olssoni. Two additional species were described by Pilsbry and Johnson (1917, p. 179-180) as Odostomia (Eulimastoma): O. bathyraphe and O. pyrgulopsis. These appear to be the only Western Atlantic species referred to Eulimastoma.

Species described by Pilsbry and Johnson are clearly referable to Eulimastoma Bartsch. Figures are provided by Pilsbry (1922). They are from Santo Domingo and, according to the original description, they are of Oligocene age. They seem to be the oldest known Eulimastoma.

Eulimastoma harbisonae Bartsch and E. olssoni Bartsch are from the same locality in the Pliocene of Florida. The only major difference between them is the presence of an open umbilicus in E. harbisonae and a closed umbilicus in E. olssoni. They are alike in growth form, lack of sculpture, peristomal and parietal characters. In each, the peripheral angulation is weak, the whorl profile is rounded, and the body whorl is attached low on the penultimate. Extreme onotogenetic variation in umbilical characters of E. vetula Corgan, new species, suggests that umbilical morphology lacks great classificatory significance in Eulimastoma. The two nominal species are here believed synonyms.

Eulimastoma olssoni Bartsch differs from E. vetula Corgan, new species, in all characters listed above as points of similarity between E. olssoni and E. harbisonae.

Eulimastoma vetula Corgan, new species, seems nearest to the Oligocene Eulimastoma bathyraphe (Pilsbry and Johnson). This species is known only from the type which measures 1.5 mm in length and .8 mm in diameter at 4.5 whorls. It is thus quite close to E. vetula in size; however, in E. bathyraphe the peripheral keel is not sufficiently pronounced to modify the aperture and the basal profile becomes concave near the aperture. Still, the two species are very close and collecting in the Neogene may eventually show a gradient from E. bathyraphe to E. vetula.

In the modern fauna, the only species which bears a significant resemblance to E. vetula is Odostomia weberi Morrison (1965, p. 221). This species, which was described from the Louisiana Coast, is here referred to Kilatus Corgan, new genus, and is discussed under that heading.

Derivation of Name.- From the Latin vetula, in the sense of aged, in allusion to the appearance of the heavily reinforced older portion of the shell.

Occurrence and Abundance.- SP 6 (22); PAL 7 (1).

Holotype.- LSUDGMTC 7349.

Figured Specimens.- LSUDGMTC 7346, 7348-9.

Eulimastoma species A

Plate X, Figure 7

Description.- *Eulimastoma* with peripheral angulation variable, generally weak; without other sculpture; umbilicus well developed in all known specimens; thin-shelled; columellar plication weak; parietal tooth first becomes evident about third post-protoconch whorl; whorl profile rounded; peristome continuous; protoconch completely immersed; protoconch coiling not evident; most mature specimen about 3.3 post-protoconch volutions, 1.20 mm in length with a .76 mm width and a .50 by .36 mm smoothly elliptical aperture.

Remarks.- *Eulimastoma* species A shows considerable variability and is known only from immature specimens. The ten known specimens do not show a clear tendency to approach a limiting number of whorls and there are no thickenings of the shell that can be interpreted as an adult feature.

Though Bartsch (1955, p. 82-83) provides very little information on *E. olssoni* (= *E. olssoni* and *E. harbisonae*), specimens with about 6 whorls are said to be .8 to .9 mm in diameter. Since *Eulimella* species A with 3.3 whorls are almost this same width, the taxa seem distinct. *Eulimella olssoni* is discussed at length in the comparison of *E. vetula* Corgan, new species, above.

Though *Eulimella* species A appears to be a new species, specimens at hand are not sufficient to permit a clear, unequivocal characterization that could be recognized by later workers.

Occurrence and Abundance.- SP 6 (6); PAL 7 (4).

Figured Specimen.- LSUDGMTC 7425

Genus KILATUS Corgan, new genus

Type Species.- Here designated, Kilatus pondella Corgan, new species.

Diagnosis.- Odostomids with weakly developed columellar plication, generally without parietal tooth; growth form low pyramidal to high spired; whorls flat sided; peristome incomplete or with parietal area poorly developed; imperforate or with chink-like umbilicus; axial sculpture absent or poorly developed; sculpture of peripheral and subsutural keels; suture confined between keels with appearance of a plowed furrow; size small, known species under 2 mm.

Comparisons.- Kilatus seem nearest to Amoura Folin, 1873 (= Folinella Dall and Bartsch 1904, a genus of small content based on Amoura angguliferens Folin. Amoura has tumid spiral ridges and secondary spiral sculpture.

Content.- Kilatus pondella Corgan, new species, and Odostomia weberi Morrison.

Remarks.- From the original description of O. weberi, it is abundant and widespread in areas of reduced salinity and mature specimens are decollate. In Kilatus pondella the juvenile shell is probably secondarily thickened and mudlump faunas are not brackish. Still the basic morphology of these two species is essentially identical.

Origin of Name.- From the Latin caelatus, engraved, in allusion to the incision of the suture.

Kilatus pondella Corgan, new species

Plate IX, Figure 6

Description.- Kilatus with heavy, massive appearing shell; low pyramidal growth form; subsutural keel very well developed, peripheral keel faint; peristome incomplete; without externally apparent columellar plication; with irregular axial undulations which suggest ribbing; protoconch completely immersed, at 90° to adult axis; size, 1.84 mm in length and .98 mm in width at 4.3 post-protoconch whorls; aperture slightly broken, about .73 x .42 mm.

Comparison.- Kilatus weberi (Morrison) has a more prominent peripheral keel and a high spired, decollate growth form.

Derivation of Name.- From the Latin pondus, a weight, in allusion to the heavy appearance of the shell.

Occurrence and Abundance.- PAL 7 (1).

Holotype.- LSUDGMTC 7350.

Genus BESLA Dall and Bartsch, 1904

1904. Besla DALL AND BARTSCH, Proc. Biol. Soc. Washington, v. 17, p. 10.

Type Species.- By original designation, Chrysallida convexa Carpenter.

Original Diagnosis.- "Odostomia with postnuclear whorls sculptured similarly throughout; varices absent; axial ribs present, rounded; spiral markings consisting of several to many raided threads in the intercostal spaces, always less strongly developed than the axial ribs; intercostal spaces crossed by several spiral threads, base spirally striated." (Dall and Bartsch, 1904, p. 10).

Remarks.- Concepts of Besla have changed markedly since the genus was first diagnosed. Dall and Bartsch (1909, p. 135) explicitly limited Besla to species in which there are three spiral ribs on the spire and a variable number on the base. Later, Bartsch (1912, p. 273) extended Besla to include a species with 7 spiral ribs, without a clearly differentiated base, and with axial ribs more prominent than spiral ribs in the umbilical region. Laws (1941) noted that New Zealand species seemingly referable to Besla had a variable number of spiral ribs on the spire and very variable basal sculpture. Saurin (1959; 1961) used Besla in the sense of Laws (1941) and Bartsch (1912). He recognized four groups among the Besla of the far east (Saurin, 1959, p. 242). Only one of these corresponds closely to the original diagnosis of the genus. Yet, all seem congeneric or closely related.

Further study is needed to clarify the protoconch character of species now referred to Besla. Ontogenetic change in sculpture, in growth form, and in the prominence of the parietal tooth also require study. Besla in the modern, expanded sense may eventually prove to be a supergeneric taxon. At present, it seems best simply to provide a revised diagnosis. Besla is a Pacific group, not previously reported in the Western Atlantic fauna.

Revised Diagnosis.- Odostominids with an externally apparent tooth; with prominent, numerous axial ribs and a variable development of spiral ribs; spiral ribs almost equal axials in amplitude and are rarely developed in the region between the periphery and the suture; occasionally, a single spiral rib joins the axials at the suture, most often spiral ribs are restricted to the periphery and lower portion of the whorl; with or without a clearly differentiated base; sculpture of lower portion of whorl completely variable; growth form, prominence of tooth, coiling of protoconch, and immersion of protoconch variable.

Besla varia Corgan, new species

Plate X, Figures 1-4

Description.- Besla with abundant prosocline axial ribs in juvenile, usually becoming opisthocline or opisthocyrt in adult, numbering from 15 to 23, restricted to spire in juvenile and extending onto base in late adult, development on base strongest in prosocline individuals;

with from one to three, generally two, spiral ribs at periphery, opisthocyrt individuals frequently develop spirally aligned axial nodes at the sutural margin; prosocline individuals have a single peripheral spiral; opisthocline and opisthocyrt individuals generally have two or more peripheral spirals, in extreme prosocline specimens the single peripheral spiral may be very well developed and the body whorl tends to uncoil; rate of whorl expansion very variable, greatest in prosocline individuals and least in opisthocyrt; growth form varying from broadly pyramiform to pupate, broader forms prosocline; shell thickness varying from thin in opisthocyrt to thick in prosocline individuals; umbilicus small, chink-like, open in juveniles, becoming closed in opisthocyrt and some opisthocline individuals; axis of coiling of early protoconch at 90° to adult axis, protoconch completely immersed, apparently planorboid and few whorled; maximum number of teleoconch whorls about 3.5, generally 3 to 3.3; maximum observed size in prosocline specimens about 1.62 mm in length and .98 mm in width; maximum observed size in opisthocline and opisthocyrt individuals about 1.26 mm in length and .60 mm in width.

Comparisons.- Despite extreme variability, Besla varia seem far removed from other Besla and distinct from all pyramidellids in the Western Atlantic fauna. The most comparable Western Atlantic species have been placed in Tragula.

The original diagnosis of Tragula (Monterosato, 1884, p. 86) and Tryon's redescription of the type species (Tryon, 1885, p. 325, pl. 74, figs. 58, 60, 61) stress a high spired growth form, absence

of an externally apparent tooth, and presence of coarse spiral sculpture limited to the periphery. Species referred to Tragula are all very high spired. They appear thin shelled and delicate.

Two Western Atlantic species have been referred to Tragula and they are quite different. Both are more or less high spired but they lack the other characters of Tragula. These two species are Turbonilla (Tragula) gubernatoria Martin (1904, p. 224, pl. 54, fig. 15) and Turbonilla (Tragula) egressa Pilsbry and Johnson (1917, p. 178). Turbonilla egressa was later figured by Pilsbry (1922, pl. 36, fig. 13).

The generic reference of these species is not clear from published descriptions and figures. Though both appear to be turbonillids, they are the described Western Atlantic species most like Besla varia. Both have more whorls and reach greater size than B. varia. Besla varia also has a flatter whorl profile and a more apparent parietal tooth.

Variability.- In some Besla varia, juvenile sculpture is distinct from that of the adult. In others, this is not true or less true. In addition to this primary variability, specimens differ from each other in the relative development and absolute number of ribs, in proportions, and rate of whorl expansion.

Superficial study might suggest a number of distinct species but all seem united by strong similarity in the early juvenile and more or less transitional sculptural patterns in the late adult.

Retention of juvenile character by adult gastropods sometimes results from gonadial parasitism but parasitism also causes a

deflection of the axis of growth. Newell (1949) gives an extensive bibliography and in the various cases discussed, parasitically induced variability seems different from that of Besla varia.

Derivation of Name.- From the Latin varia, varying, in allusion to the ontogenetic variation in sculpture.

Occurrence and Abundance.- SP 6 (9); PAL 7 (27).

Holotype.- LSUDGMTC 7352.

Figured Specimens.- LSUDGMTC 7352-7354, 7392.

Subfamily CHRYSALLIDINAE Saurin, 1958

1958. Chrysallidinae SAURIN, Ann. Fac. Sci. Saigon, 1948, p. 64.

Diagnosis.- Pyramidellids of pupate or globular to moderately high spired growth form; few to many whorls; protoconch heterostrophic, generally immersed; never with more than one columellar plication, plication generally well developed, occasionally absent; frequently with an externally evident parietal tooth; both spiral and axial sculpture generally well developed, generally ornate; size minute to large.

Remarks.- Saurin (1958, p. 64) appears to be the first author to introduce a familial-level term for this group.

Genus CHRYSALLIDA Carpenter, 1856

1856. Chrysallida CARPENTER, Proc. Zool. Soc. London, 1856, p. 170.

Type Species.- By monotypy, Chemnitzia communis C. B. Adams.

Diagnosis.- Chrysallidinae with axial and spiral sculpture of spire different from that of base; sculpture of spire generally granular or nodular at intersection of spiral and axial elements; growth form pupoid to high spired; protoconch generally immersed, of few whorls; size range, reaching 7 mm or more, generally under 3 mm.

Remarks.- According to Dall and Bartsch (1909, p. 142), Carpenter (1857, p. 419) misidentified Chemnitzia communis C. B. Adams. Dall and Bartsch incorrectly attribute authorship of Chrysallida to Carpenter in the work in which they regard Chemnitzia communis as misidentified. They then offer Odostomia (Chrysallida) torrita Dall and Bartsch as a replacement for Chrysallida communis [C. B. Adams] Carpenter not Chemnitzia communis C. B. Adams. Dall and Bartsch (1909) and many later workers treat Odostomia torrita Dall and Bartsch as the type species, by subsequent designation, of Chrysallida.

Actually, Chrysallida was established in 1856 (Carpenter, 1856, p. 170) and is monotypic for Chemnitzia communis C. B. Adams. As Palmer (1958, p. 244) has noted, a subsequent misidentification, or possible misidentification, has no bearing on the validity of an earlier type designation or identification.

When Adams (1852, p. 390) described Chemnitzia communis, he characterized it as "long, fusiform conic," with axial ribs becoming

obsolete. In these features, it is distinct from many species that have, historically, been referred to Chrysallida. The original description of Chemnitzia communis was unillustrated and the type lot contained specimens of at least three species (Dall and Bartsch, 1909). Turner (1956, pl. 10, fig. 5) provides a good illustration of a specimen she designates as the lectotype.

The lectotype has five moderately prominent spiral ribs fully exposed on the spire. Most Chrysallida have fewer spirals and in these species the spirals are generally coarser than those of C. communis.

CHRYSALLIDA (CHRYSALLIDA) Carpenter, 1857

Type Species.- As for genus.

Diagnosis.- Chrysallida with axial and spiral ribs on spire, with prominent spiral cords and, generally, with microscopic decussate axial lines on base; periphery generally with accented spiral sculpture; growth form moderately high spired; size, small to large.

Remarks.- In the mudlump fauna, Chrysallida s.s. is represented by juveniles of three species. One species is new. The other two, though not specifically determinate, seem close to described taxa.

Western Atlantic Chrysallida s.s. are fairly well known. Only two species remain unillustrated: Odostomia (Chrysallida) nioba Dall and Bartsch (1911, p. 286) and O. (Menestho) beauforti Jacot (1921, p. 139). Though Jacot's species is described as Odostomia

(Menestho), it is characterized by comparison with Chrysallida seminuda (C. B. Adams). Jacot considers it possibly a "mutation" of C. seminuda.

Chrysallida (Chrysallida) species A

Plate IX, Figure 9

Description.- Chrysallida (Chrysallida) with spiral sculpture more prominent than axial; about 20 coarsely beaded axial ribs on the third post-protoconch whorl; axial ribs restricted to spire, beads spirally elongate; spiral sculpture of 3 ribs on the spire, 5 or more on the whorl base; lowest spiral rib of spire and upper ribs of base smooth, not nodulate, prominent, forming a bicarinate periphery on body whorl, basal carina overridden by younger whorls resulting in a unicarinate spire; numerous decussate axial riblets between spiral ribs of base; peristome complete but thin in parietal area; parietal tooth well developed; protoconch slightly emergent, at about 120° to adult axis, apparently very low spired, helicoid, few whorled; size of only known individual 1.35 mm in length and .81 mm in width at 3.3 post-protoconch whorls; aperture elliptical, .36 x .26 mm.

Comparisons.- Small size and subdued basal sculpture suggest that Chrysallida species A is known only from an immature specimen. Basal sculpture is clearly delineated and a specimen of 4 or more whorls would probably have sharply elevated cords. Chrysallida species A appears to be an undescribed species referable to the same species complex as Chrysallida dux (Dall and Bartsch).

One or more peripheral keels and a few coarsely beaded spirals on the spire characterize this group. Present records suggest this is essentially a Pacific group but Wells and Wells (1961, p. 151, fig. 4) recently recorded Chrysallida dux, itself, from the coast of North Carolina. Their identification seems sound. Dall and Bartsch (1906, p. 350, pl. 17, fig. 4) originally described the species as coming from Japan. Their specimens were, apparently, mislocated.

Laws (1941, p. 16) recorded an unnamed and unillustrated Chrysallida similar to C. dux from the Neogene of New Zealand and Saurin (1961, p. 232) records this species as Miralda dux, from Viet-Nam. Neither of these unillustrated Pacific records seems as impressive as figure 4 in Wells and Wells (1961).

Chrysallida species A is much smaller than C. dux of comparable whorl count. In addition, C. dux has one more spiral rib on the spire, a single peripheral keel, and the basal sculpture is diffuse, rather than sharply defined.

Remarks.- If formally named, Chrysallida species A would be more readily recognizable than many nominal species of pyramidellids. Still, lack of sure knowledge of variability and adult basal sculpture appears to make naming undesirable.

Occurrence and Abundance.- SP 6 (1).

Figured Specimen.- LSUDGMTC 7429.

Chrysallida (Chrysallida) species B

Plate IX, Figure 5

Description.- Chrysallida (Chrysallida) with axial sculpture more pronounced than spiral; with 12 to 16 axial ribs at 2.3 to 2.5 post-protoconch whorls; axial ribs bear very prominent, axially aligned, spirally elongate beads; axial macrosculpture restricted to spire; spiral sculpture of three equal to subequal ribs on the spire and two or more spiral ribs on the base; numerous faint axial lirations present between basal spirals; parietal tooth small, sharply elevated; protoconch immersed, essentially normal to adult axis, helicoid, few-whorled; largest specimen .80 mm in length and .62 mm in width at 2.5 post-protoconch whorls; apertures of available specimens broken, about .42 x .25 mm.

Remarks.- Coarse beads and equal to subequal spirals distinguish this species from other mudlump Chrysallida (Chrysallida). The general pattern of ornamentation is fairly common and material is not adequate for specific determination. Chrysallida species B bears a rather strong resemblance to two nominal species of Chrysallida described by Bartsch (1955) from the Pliocene of Florida: C. cookei and C. dalli.

Occurrence and Abundance.- SP 6 (2).

Figured Specimen.- LSUDGMTC 7428.

Chrysallida (Chrysallida) species C
Plate IX, Figure 4

Description.- Chrysallida (Chrysallida) with spiral and axial sculpture of spire more or less equally developed; without nodes or with a few indistinct nodes at intersection of spiral and axial sculpture; 18 axial ribs at 2 post-protoconch whorls; 4 spiral ribs on spire, the last somewhat more prominent, about 5 spirals on base; axial microsculpture of base abundant, unusually prominent; peristome incomplete; parietal tooth small, well defined; protoconch partly immersed, at 90° to adult axis, helicoid, apparently of 2 or 3 whorls; size .82 mm in length and .53 mm in width at 2 post-protoconch whorls; aperture .38 x .20 mm.

Remarks.- Presence of a fully sculptured base suggests that the single, known individual of Chrysallida species C may show all adult sculptural features. Yet, sculpture of the base is rather faint and would, presumably, become more pronounced and different later in ontogeny.

This species can be distinguished from other mudlump Chrysallida by its equal spiral and axial sculpture. In the world fauna, this sculptural pattern is fairly common. Bartsch (1955) illustrates and describes two nominal species from the Pliocene of Florida that share all essential features of Chrysallida species C. These are C. macneilli and C. mansfieldi. The single specimen of Chrysallida species C is too young to permit meaningful comparison.

Occurrence and Abundance.- SP 6 (1).

Figured Specimen.- LSUDGMTC 7426.

CHRYSALLIDA (FARGOA) Bartsch, 1955

1955. Fargoa BARTSCH, Smithsonian Misc. Coll., v. 125, p. 80

Type Species.- By original designation, Fargoa calesi Bartsch.

Original Description.- "Shell minute, pupoid, having axial ribs and four strong spiral cords that render the ribs nodulose on the first three whorls and less so on the fourth. The axial ribs and the first two spiral cords are more closely approximated than the rest and form a dumbbell-shaped sculpture below the summit of the whorls. The base is marked by spiral cords." (Bartsch, 1955, p. 80).

Remarks on Original Description.- Bartsch proposed Fargoa as a genus, placed next to Miralda (Miraldella) in his key (Bartsch, 1955, p. 7). The original diagnosis seems overly restrictive and places great emphasis on characters that have, at most, specific value.

Revised Diagnosis.- Chrysallida of small size and more or less pupoid growth form; spire sculptured by axial and spiral ribs; base with spiral cords, axial sculpture of base generally a less pronounced continuation of axial ribs of the spire; sculpture generally more or less nodular at intersection of spiral and axial elements.

Remarks.- Sculpture in Chrysallida (Fargoa) is very similar to that in the nominate subgenus but in general basal axials are more prominent and more clearly related to the axials of the spire. In addition, the pupate growth form and small size are fairly distinctive.

In the world fauna, Chrysallida (Chrysallida) and Chrysallida (Fargoa) appear to intergrade, though transitional forms are not common. Evaluation of Fargoa as a taxon should involve quantitative study of its distinction from Chrysallida and studies of phylogeny. In the interim, it appears to be a practical unit.

Chrysallida (Fargoa) gaudens Corgan, new species

Plate IX, Figure 3

Description.- Chrysallida (Fargoa) with 18 to 20 fine axial ribs on body whorl; axial ribs extending from spire onto base, becoming obsolete; axial more or less decussate on spire becoming more decussate on base; spiral sculpture of 4 to 5 subequally placed ribs on spire that vary from minute lirations to prominent ribs, with 2 prominent spiral cords on basal margin of whorl and 4 prominent spiral ribs on base; intersection of spiral and axial sculpture rarely nodular, spirals of spire generally developed between axials; umbilicus hardly developed, small, chink-like; parietal wall without tooth and internal columella free of plication; protoconch-teleoconch boundary sharp, marked by a minute varix; protoconch at 90° to adult axis, completely immersed, apparently helicoid, few whorled; maximum observed adult

size .86 mm in length and .50 mm in width at 2.5 post-protoconch whorls; aperture elliptical, .36 x .20 mm.

Comparisons.- The unusually small size of Chrysallida gaudens, coupled with the total absence of a columellar plication or parietal tooth suggests that all known individuals are juveniles. Yet the sculpture is complete: basal spirals are well developed and these are generally added late in ontogeny.

Whether juvenile or not, the sculpture of C. gaudens is so distinctive that the species should be readily recognizable. The most similar species appears to be Fargoa archeri Bartsch, from the Pliocene of St. Petersburg, Florida (Bartsch, 1955, p. 81, pl. 16, fig. 4). In this species the two subsutural spiral cords are more closely spaced than other spirals. Numerous axial ribs interact to form a series of dumbbell-like ornaments below the suture. In Chrysallida (Fargoa) gaudens Corgan, new species, spiral ribs are more or less equidistant and nodules, if present, are subdued.

Derivation of Name.- From the Latin gaudens, in the sense of decorative, in allusion to the ornate sculpture.

Occurrence and Abundance.- SP 6 (8).

Holotype.- LSUDGMTC 7344.

Figured Specimen.- LSUDGMTC 7344.

PLATE I

Fig. 1. Cadulus (Gadila) cheethami Corgan, n. sp. PAL 7. Paratype. LSUDGMTC 7464. Magnification X 75. Transverse thin-section.

Fig. 2. Cadulus (Gadila) cheethami Corgan, n. sp. PAL 7. Paratype. LSUDGMTC 7470. Length 15.3 mm. Magnification X 5. Whole specimen X-ray, specimen with weak opacity banding.

Fig. 3. Cadulus (Gadila) cheethami Corgan, n. sp. PAL 7. Paratype. LSUDGMTC 7468. Length 15.5 mm. Magnification X 5. Whole specimen X-ray, specimen with strong opacity banding.

Fig. 4. Cadulus (Gadila) cheethami Corgan, n. sp. PAL 7. Paratype. LSUDGMTC 7469. Length 16.3 mm. Magnification X 5.

Fig. 5. Cadulus (Gadila) cheethami Corgan, n. sp. PAL 7. Holotype. LSUDGMTC 7471. Length 17 mm. Magnification X 10.

Fig. 6. Cadulus (Gadila) cheethami Corgan, n. sp. PAL 7. Paratype. LSUDGMTC 7465. Magnification X 85.


PLATE I

PLATE II

Fig. 1. Cadulus (Gadila) acus Dall, 1889? SP 6. LSUDGMTC 7366. Length 5.84 mm. Magnification X 34.

Fig. 2. Cadulus (Sulcogadila ?) louisianae Corgan, n. sp. PAL 7 Holotype. Length 4.36 mm. Magnification X 30.

Fig. 3. Eulimastoma vetula Corgan, n. sp. SP 6. Paratype. Length 1.35 mm. Magnification X 31.

Fig. 4. Circulus pentagonus (Gabb), 1873. LSUDGMTC 7383. Length 1.38 mm. Magnification X 32.

Fig. 5. Same as Fig. 4.

Fig. 6. Same as Fig. 2. Magnification X 33.

PLATE II

PLATE III

Fig. 1. Cadulus (Platyschides) howei Corgan, n. sp. PAL 7. Holotype. LSUDGMTC 7456. Length 3.37 mm. Magnification X 33. Note opacity bands.

Fig. 2. Cadulus (Platyschides) hilgardi Corgan, n. sp. SP 1-B, - 456.75 to 456.95'. Paratype. LSUDGMTC 7451. Length 5.22 mm. Magnification X 33.

Fig. 3. Same as Figure 1.

Fig. 4. Cadulus (Platyschides) howei Corgan, n. sp. PAL 7. Paratype. LSUDGMTC 7452. Length 2.63 mm. Magnification X 32. An ostensive definition of opacity banding.

Fig. 5. Cadulus (Platyschides) hilgardi Corgan, n. sp. SP 1-B, - 456.75 to 456.95'. Holotype. LSUDGMTC 7457. Length 5.20 mm. Magnification X 33. Note opacity bands.

PLATE III

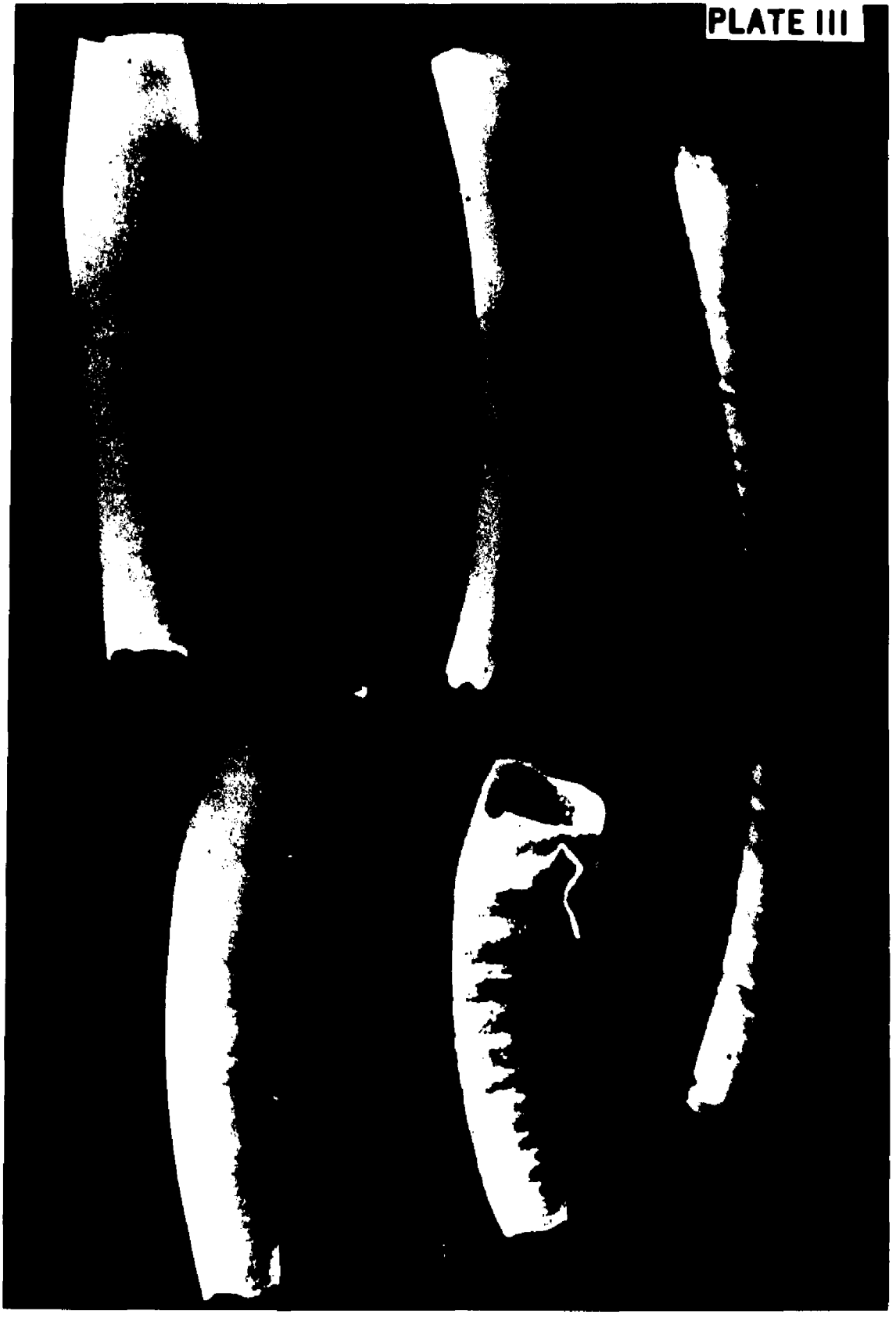


PLATE IV

Fig. 1. Cadulus (Sulcogadila) anderseni Corgan, n. sp. PAL 7. Paratype. LSUDGMTC 7379. Length 1.70 mm. Magnification X 30.

Fig. 2. Same as Figure 1.

Fig. 3. Cadulus (Sulcogadila) anderseni Corgan, n. sp. PAL 7. Holotype. LSUDGMTC 7378. Length 1.70 mm. Magnification X 32.

Fig. 4. Same as Figure 3.

Fig. 5. Cadulus (Gadila) iota Henderson, 1920. Holotype. USNM 161581. Length 2.18 mm. Magnification X 33.

Fig. 6. Cadulus (Gadila) minusculus Dall, 1889. Lectotype, designated by Henderson (1920, p. 134). USNM 93122. Length 2.20 mm. Magnification X 33.

Fig. 7. Cadulus (Sulcogadila ?) nanus Clench and Aguayo, 1939. MCZ 8922. Length 1.80 mm. Magnification X 32.

Fig. 8. Same as Figure 7.

Fig. 9. Cadulus (Sulcogadila) morgani Corgan, n. sp. SP 6. Holotype. LSUDGMTC 7455. Length 1.96 mm. Magnification X 30.

Fig. 10. Same as Figure 9.

PLATE IV

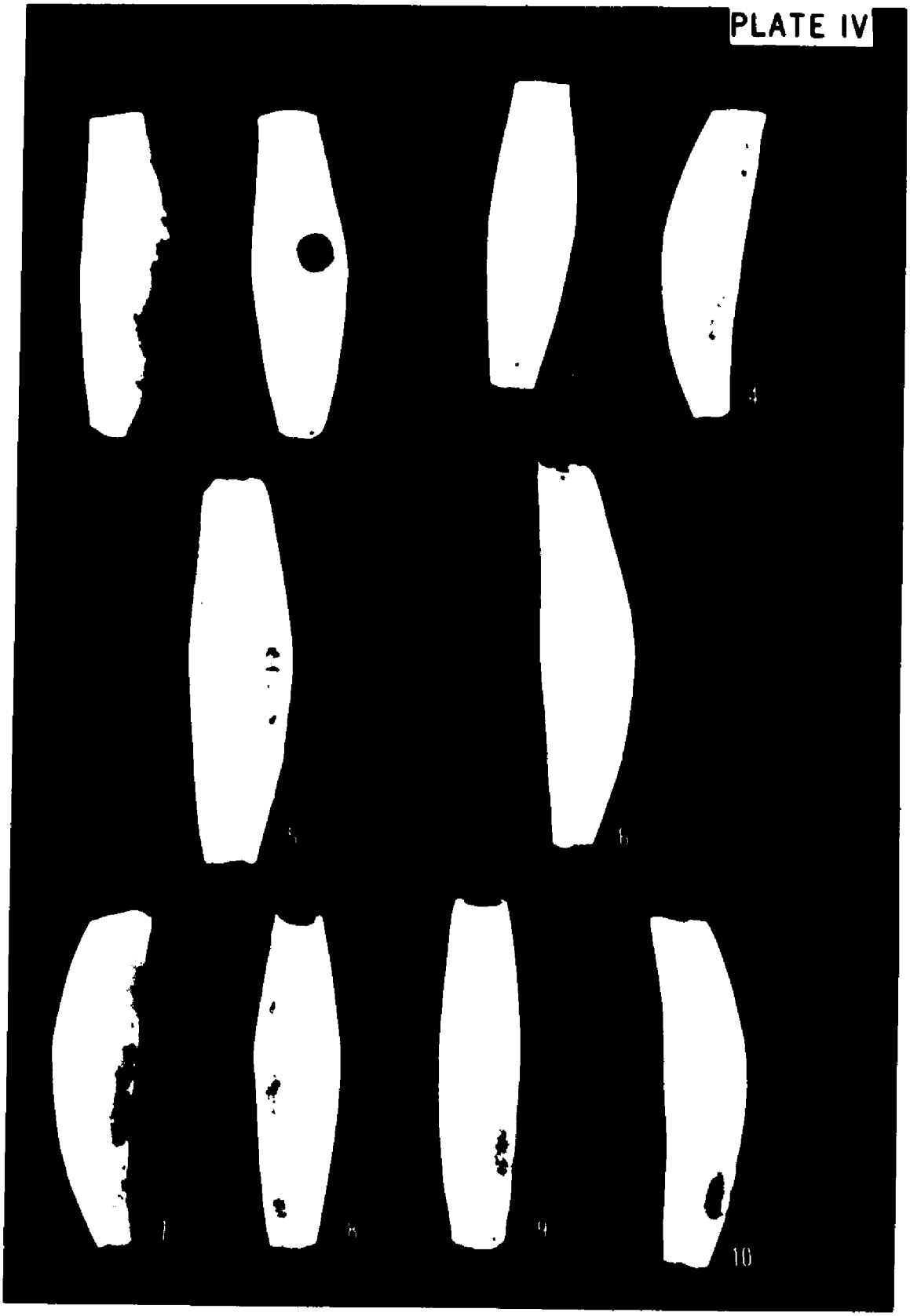


PLATE V

Fig. 1. Arene lis Corgan, n. sp. PAL 7. Holotype. LSUDGMTC 7359. Maximum diameter 3.44 mm. Magnification X 31. Adult stage.

Fig. 2. Arene lis Corgan, n. sp. SP 5. Paratype. LSUDGMTC 7360. Maximum diameter .98 mm. Magnification X 35. Nodular, low spired juvenile.

Fig. 3. Same as Figure 2.

Fig. 4. Same as Figure 2.

Fig. 5. Arene lis Corgan, new species. SP 1-B, -8.25 to 8.38'. Paratype. LSUDGMTC 7361. Maximum diameter 2.24 mm. Magnification X 35.

PLATE VI

Fig. 1. Alvinia auberiana (Orbigny), 1841. SP 1-B, -350.9 to 351.1'. LSUDGMTC 7342. Length 1.24 mm. Magnification X 35.

Fig. 2. Same as above. Note protoconch-teleoconch relationship.

Fig. 3. Aorotrema nicholsi Corgan, n. sp. SP 94. Holotype. LSUDGMTC 7377. Length 1.21 mm. Magnification X 35. Note protoconch-teleoconch relationship.

Fig. 4. Same as above.

Fig. 5. Same as above.

Fig. 6. Zebinella decussata (Montagu), 1803. PAL 7. LSUDGMTC 7372. Length 3.24 mm. Magnification X 21.

Fig. 7. Zebina (Iopsis) browniana (Orbigny), 1841. PAL 7. LSUDGMTC 7374. Length 3.04 mm. Magnification X 34.

Fig. 8. Phosinella cancellata (Orbigny), 1847. SP 5. LSUDGMTC 7373. Length 4.04. Magnification X 30.

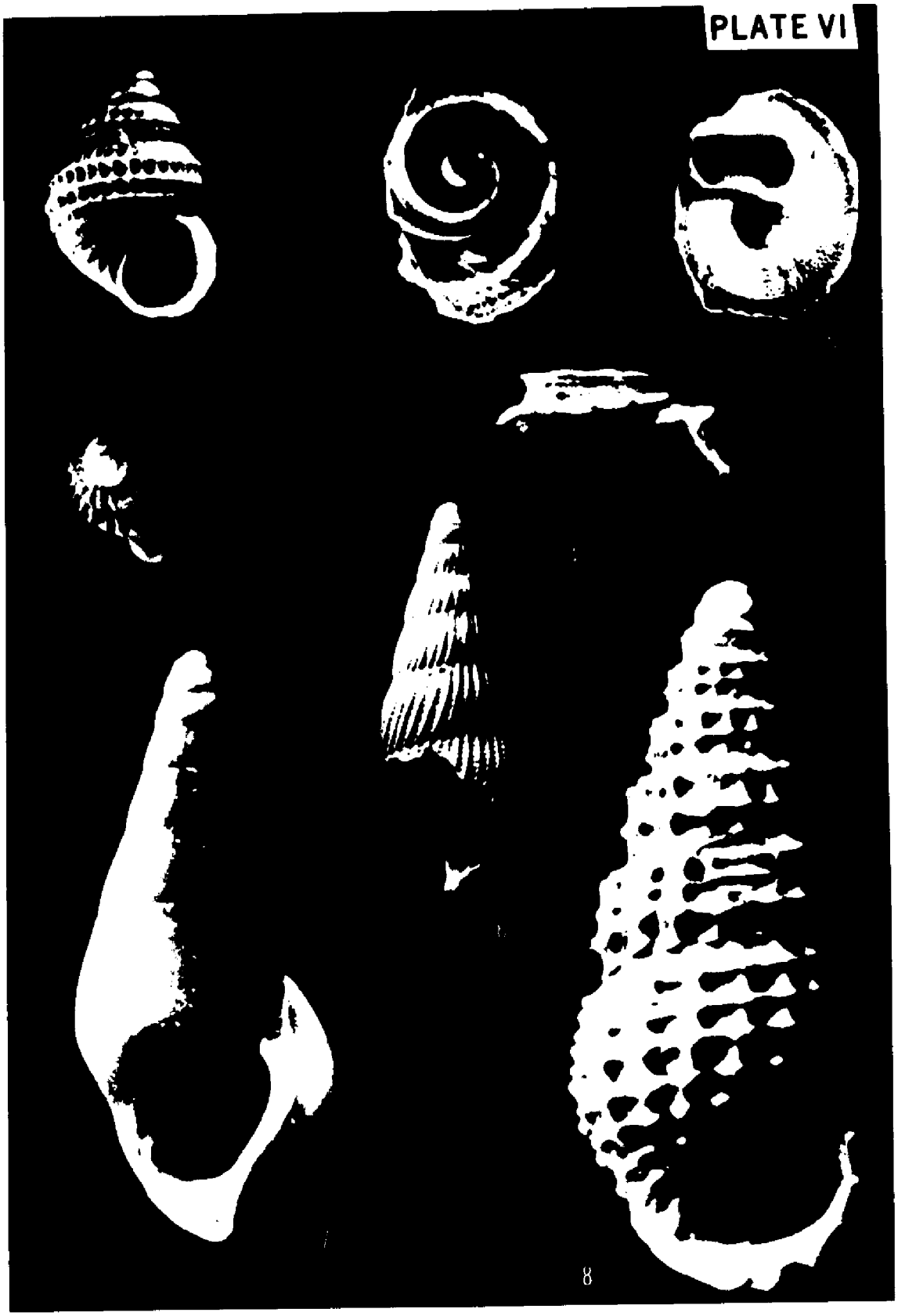


PLATE VI

PLATE VII

Fig. 1. Cerapons simulator Corgan, n. gen., n. sp. SP 5. Holotype. LSUDGMTC 7387. Maximum diameter 1.64 mm. Magnification X 34.

Fig. 2. Same as Figure 1. Note heterostrophic protoconch.

Fig. 3. Circulus pentagonus (Gabb), 1873. California Academy of Sciences Locality 27288, Gulf of Panama. Maximum diameter 1.51 mm. Magnification X 33.

Fig. 4. Same as Figure 3.

Fig. 5. Circulus pentagonus (Gabb), 1873. SP 94. LSUDGMTC 7382. Maximum diameter 1.92 mm. Magnification X 35.

Fig. 6. Same as Figure 5.

Fig. 7. Cerapons simulator Corgan, n. gen., n. sp. SP 5. Paratype. LSUDGMTC 7388. Maximum diameter 1.26 mm. Magnification X 33.

Fig. 8. Same as Figure 7. Note heterostrophic protoconch.

PLATE VII

PLATE VIII

Fig. 1. Episcynia inornata (Orbigny), 1841. SP 94. LSUDGMTC 7343. Maximum diameter 2.75 mm. Magnification X 36.

Fig. 2. Parviturboides interruptus (C. B. Adams), 1850. SP 1-B, - 350.9 to 351.1'. Maximum diameter 1.30 mm. Magnification X 32.

Fig. 3. Same as Figure 2.

Fig. 4. Same as Figure 1.

Fig. 5. Same as Figure 1.

Fig. 6. Same as Figure 2.


PLATE VIII

PLATE IX

Fig. 1. Syrnola ampla Corgan, n. sp. PAL 7. Holotype. LSUDGMTC 7396. Length 3.24 mm. Magnification X 32.

Fig. 2. Vitrinella meta Corgan, n. sp. SP 1-B, - 348.8 to 349.0'. Holotype. LSUDGMTC 7384. Length 1.7 mm. Magnification X 35.

Fig. 3. Chrysallida (Fargoa) gaudens Corgan, n. sp. SP 6. Holotype. LSUDGMTC 7344. Length .86 mm. Magnification X 37.

Fig. 4. Chrysallida (Chrysallida) sp. C. SP 6. LSUDGMTC 7426. Length .82 mm. Magnification X 32.

Fig. 5. Chrysallida (Chrysallida) sp. B. SP 6. LSUDGMTC 7428. Length .80 mm. Magnification X 33.

Fig. 6. Kilatus pondella Corgan, n. gen., n. sp. PAL 6. Holotype. Length 1.84 mm. Magnification X 32.

Fig. 7. Syrnola meridiana Corgan, n. sp. PAL 7. Holotype. LSUDGMTC 7357. Length 3.04 mm. Magnification X 34.

Fig. 8. Same as Figure 2.

Fig. 9. Chrysallida (Chrysallida) sp. A. SP 6. LSUDGMTC 7429. Length 1.35 mm. Magnification X 32.

Fig.10. Longchaeus candidus (Moerch), 1875. PAL 7. LSUDGMTC 7356. Length 4.80 mm. Magnification X 35.


PLATE IX

PLATE X

Fig. 1. Besla varia Corgan, n. sp. SP 6. Holotype. LSUDGMTC 7352. Length 1.27 mm. Magnification X 33.

Fig. 2. Besla varia Corgan, n. sp. PAL 7. Paratype. LSUDGMTC 7353. Length 1.25 mm. Magnification X 34.

Fig. 3. Besla varia Corgan, n. sp. PAL 7. Paratype. LSUDGMTC 7354. Length 1.34 mm. Magnification X 34.

Fig. 4. Besla varia Corgan, n. sp. PAL 7. Paratype. LSUDGMTC 7392. Length 1.52 mm. Magnification X 34.

Fig. 5. Eulimastoma vetula Corgan, n. sp. SP 6. Holotype. LSUDGMTC 7349. Length 1.36 mm. Magnification X 30.

Fig. 6. Eulimastoma vetula Corgan, n. sp. PAL 7. Paratype. LSUDGMTC 7346. Length 1.32 mm. Magnification X 33.

Fig. 7. Eulimastoma sp. A. PAL 7. LSUDGMTC 7425. Length 1.10 mm. Magnification X 32.

Fig. 8. Elephantanellum imbricatum (Carpenter), 1856. SP 6. LSUDGMTC 7340. Length 2.40 mm. Magnification X 33.

Fig. 9. Micranellum regulare (Carpenter), 1856. SP 6. LSUDGMTC 7341. Length 1.83 mm. Magnification X 34.

Fig.10. Turbonilla (Turbonilla) flexio Corgan, n. sp. SP 6. Holotype. LSUDGMTC 7440. Length 2.24 mm. Magnification X 32.

Fig.11. Turbonilla (Turbonilla) flexio Corgan, n. sp. SP 6. Paratype. LSUDGMTC 7441. Length 2.82 mm. Magnification X 34.

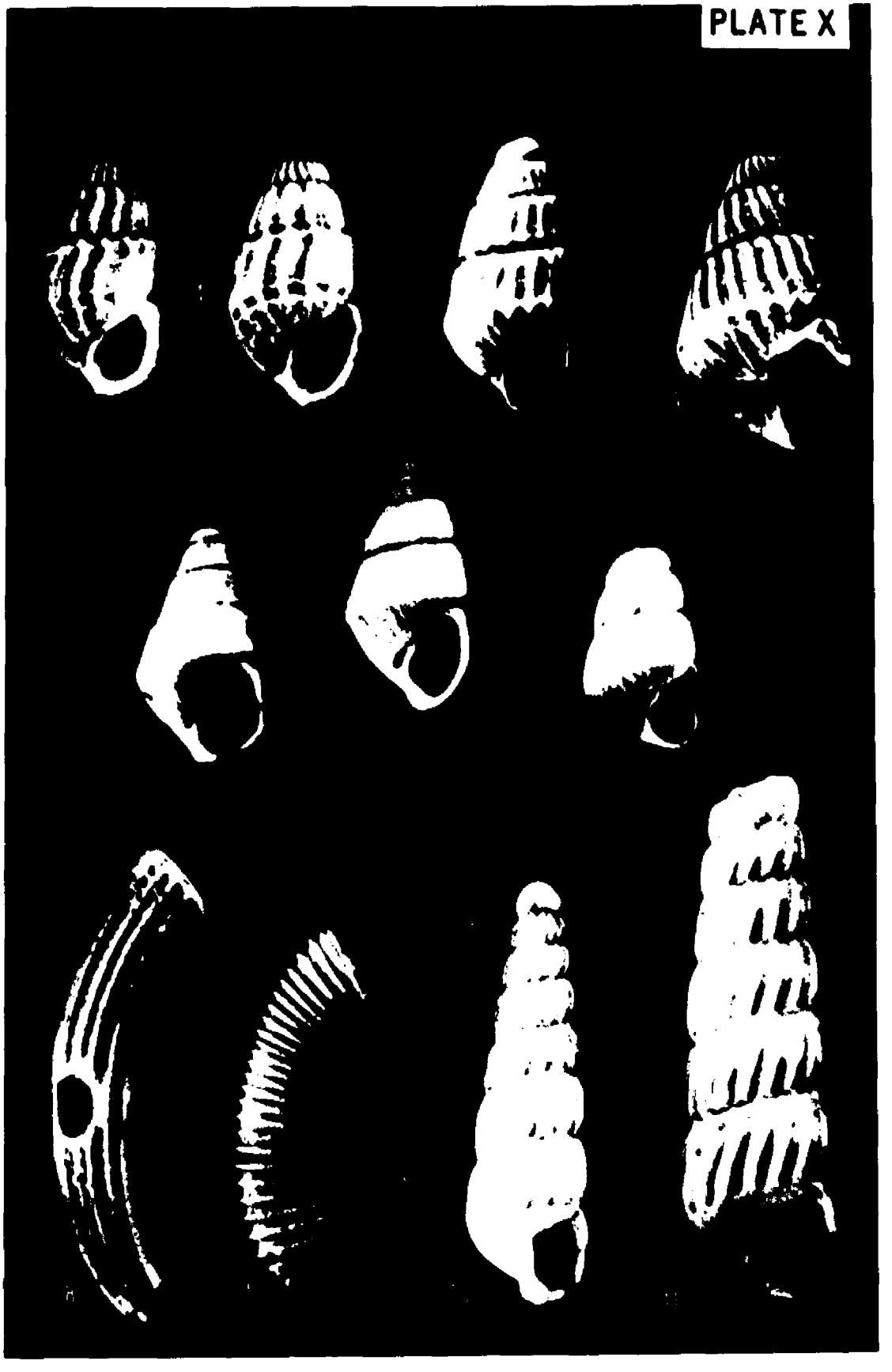


PLATE X

PLATE XI

Fig. 1. Turbonilla (Turbonilla) erwini Corgan, n. sp. SP 6. Holotype. LSUDGMTC 7358. Length 2.17 mm. Magnification X 35.

Fig. 2. Turbonilla (Turbonilla) fustis Corgan, n. sp. SP 6. Paratype. LSUDGMTC 7445. Length 1.50 mm. Magnification X 33.

Fig. 3. Turbonilla (Turbonilla) procera Corgan, n. sp. PAL 7. Paratype. LSUDGMTC 7414. Length 4.48 mm. Magnification X 32.

Fig. 4. Turbonilla (Turbonilla) procera Corgan, n. sp. PAL 7. Paratype. LSUDGMTC 7410. Length 2.70 mm. Magnification X 32.

Fig. 5. Turbonilla (Pyrgiscus) butlerae Corgan, n. sp. PAL 7. Holotype. LSUDGMTC 7404. Length 1.92 mm. Magnification X 32.

Fig. 6. Turbonilla (Turbonilla) confinium Corgan, n. sp. PAL 7. Holotype. LSUDGMTC 7406. Length 4.10 mm. Magnification X 31.

Fig. 7. Turbonilla (Turbonilla) fustis Corgan, n. sp. SP 6. Holotype. LSUDGMTC 7398. Length 2.30 mm. Magnification X 32.

Fig. 8. Turbonilla (Turbonilla) baca Corgan, n. sp. PAL 7. Holotype. LSUDGMTC 7367. Length 3.00 mm. Magnification X 31.

Fig. 9. Turbonilla (Turbonilla) procera Corgan, n. sp. PAL 7. Holotype. LSUDGMTC 7413. Length 3.68 mm. Magnification X 34.

PLATE XI

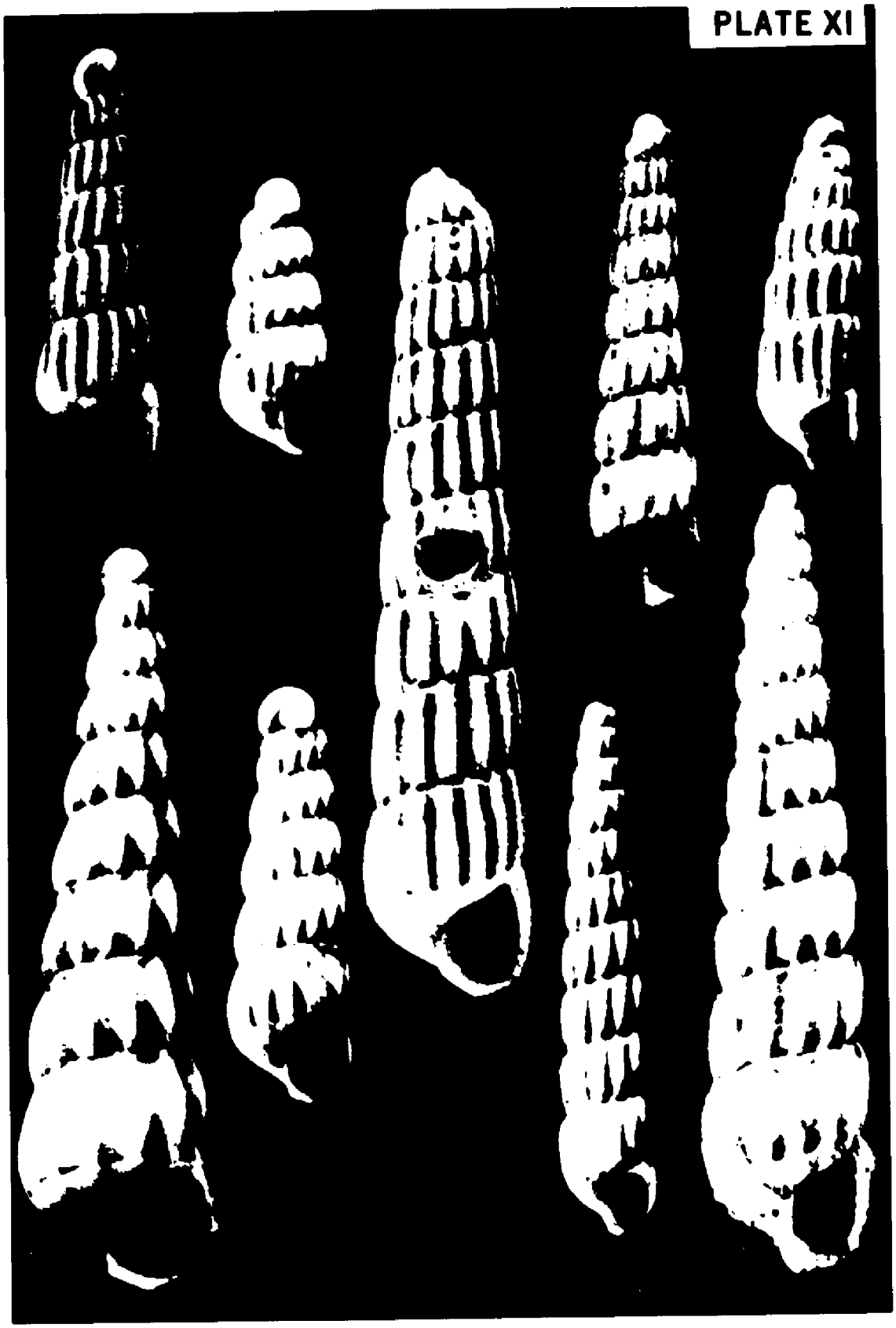


Fig. 10. Turbonilla (Turbonilla) asperella Corgan, n. sp. SP 6. Holotype. LSUDGMTC 7393. Length 4.46 mm. Magnification X 32.

Fig. 11. Turbonilla (Turbonilla) conferta Corgan, n. sp. SP 5. Paratype. LSUDGMTC 7418. Length 2.10 mm. Magnification X 32.

Fig. 12. Turbonilla (Turbonilla) uncina Corgan, n. sp. PAL 7. Paratype. LSUDGMTC 7444. Length 1.84 mm. Magnification X 32.

Fig. 13. Turbonilla (Turbonilla) buskirkae Corgan, n. sp. SP 6. Holotype. LSUDGMTC 7401. Length 3.15 mm. Magnification X 33.

PLATE XII

Fig. 1. Turbonilla (Turbonilla) conferta Corgan, n. sp. PAL 7. Holotype. LSUDGMTC 7419. Length 1.88 mm. Magnification X 32.

Fig. 2. Turbonilla (Pyrgiscus) olus Corgan, n. sp. SP 6. Holotype. LSUDGMTC 7432. Length 1.94 mm. Magnification X 33.

Fig. 3. Turbonilla (Pyrgiscus) chenowethi Corgan, n. sp. PAL 7. Holotype. LSUDGMTC 7405. Length 2.40 mm. Magnification X 33.

Fig. 4. Turbonilla (Pyrgiscus) ellisi Corgan, n. sp. PAL 7. Holotype. LSUDGMTC 7400. Length 3.14 mm. Magnification X 33.

Fig. 5. Turbonilla (Turbonilla) conferta Corgan, n. sp. PAL 7. Paratype. LSUDGMTC 7420. Length 1.70 mm. Magnification X 34.

Fig. 6. Turbonilla (Turbonilla) heathae Corgan, n. sp. PAL 7. Holotype. LSUDGMTC 7402. Length 1.49 mm. Magnification X 35.

Fig. 7. Turbonilla (Turbonilla) uncina Corgan, n. sp. PAL 7. Holotype. LSUDGMTC 7443. Length 1.62 mm. Magnification X 32.

Fig. 8. Turbonilla (Turbonilla) apiculata Corgan, n. sp. SP 6. Holotype. LSUDGMTC 7437. Length 2.05 mm. Magnification X 33.

Fig. 9. Turbonilla (Pyrgiscus) buskirkae Corgan, n. sp. SP 5. Paratype. LSUDGMTC 7369. Length 1.91 mm. Magnification X 33.

PLATE XII

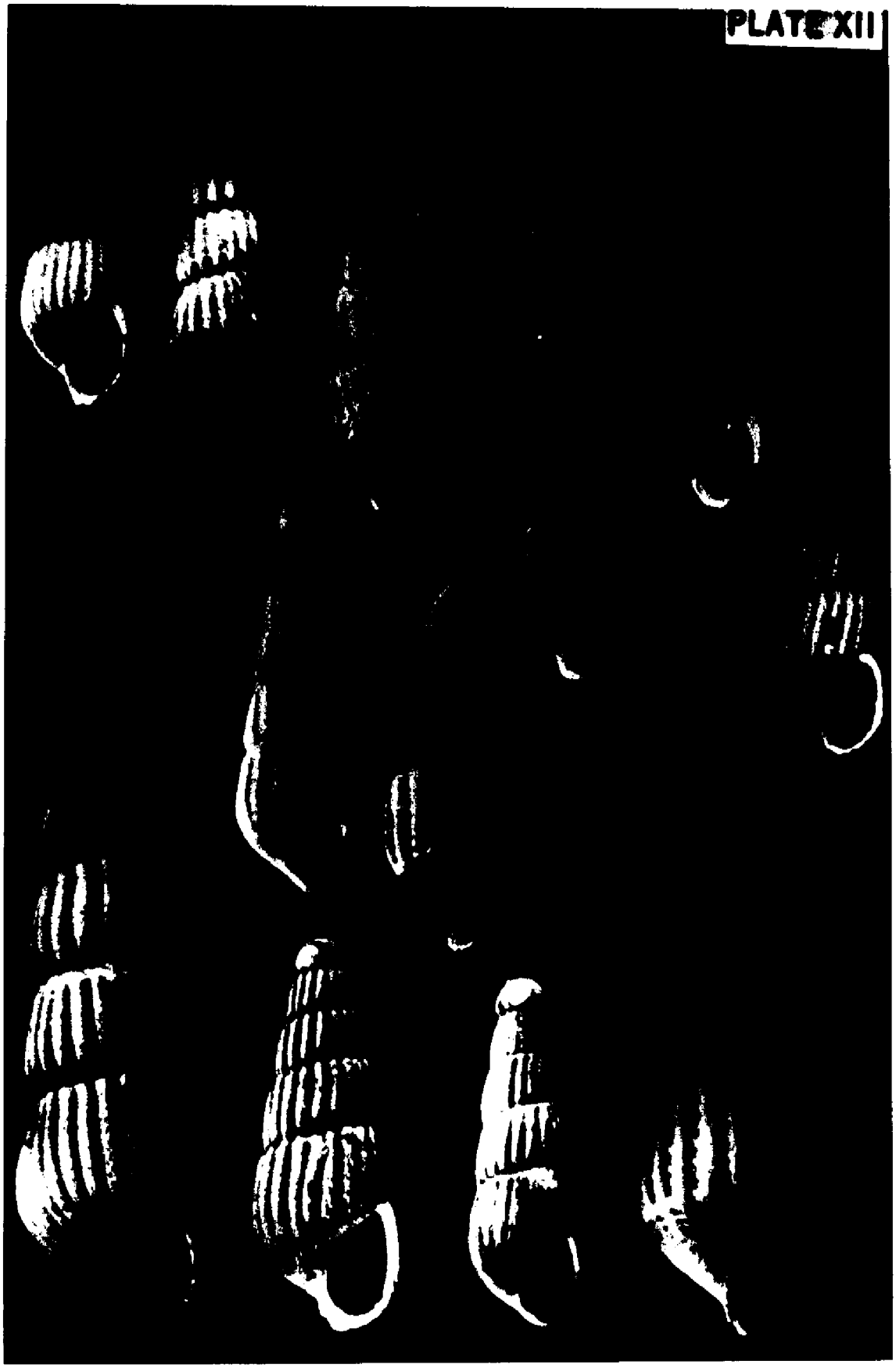


PLATE XIII

Fig. 1. Turbonilla (Pyrgiscus) rolfei Corgan, n. sp. PAL 7. Holotype. LSUDGMTC 7370. Length 6.1 mm, protoconch missing. Magnification X 32.

Fig. 2. Turbonilla (Pyrgiscus) norae Corgan, n. sp. PAL 7. Paratype. LSUDGMTC 7433. Length 3.68 mm. Magnification X 33. Normal protoconch.

Fig. 3. Turbonilla (Pyrgiscus) tabulatella Corgan, n. sp. SP 6. Holotype. LSUDGMTC 7435. Length 2.24 mm. Magnification X 33.

Fig. 4. Turbonilla (Pyrgiscus) norae Corgan, n. sp. SP 6. Holotype. LSUDGMTC 7403. Length 3.84 mm. Magnification X31. Note emergent protoconch.

Fig. 5. Turbonilla (Pyrgiscus) wilberti Corgan, n. sp. PAL 7. Holotype. LSUDGMTC 7394. Length 4.06 mm, protoconch and early whorls missing. Magnification X 31.

PLATE XIII

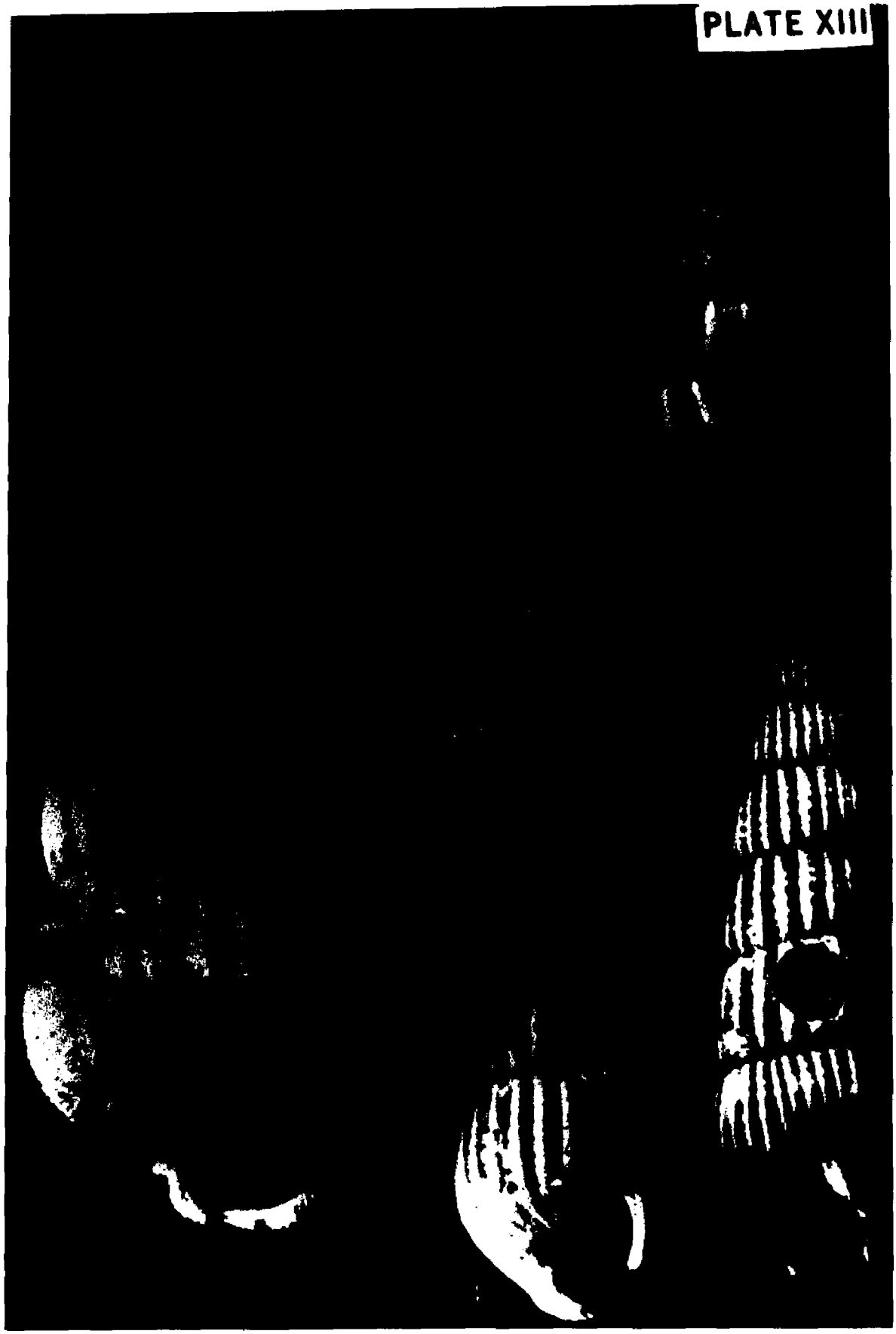


PLATE XIV

Fig. 1. Cadulus (Gadila) cheethami Corgan, n. sp. PAL 7. Paratype. LSUDGMTC 7464. Magnification X 47. Axial thin-section.

Fig. 2. Cadulus (Platyschides) howei Corgan, n. sp. PAL 7. Paratype. LSUDGMTC 7466. Magnification X 153. Transverse thin-section.

Fig. 3. Cadulus (Gadila) anderseni Corgan, n. sp. PAL 7. Paratype. LSUDGMTC 7463. Magnification X 153. Transverse thin-section.

Fig. 4. Same as Figure 1. Magnification X 563.

Fig. 5. Cadulus (Gadila) cheethami Corgan, n. sp. PAL 7. Paratype. LSUDGMTC 7465. Magnification X 571.

PLATE XIV

Appendix 1

MASTER FAUNAL LIST, MUDLUMP MOLLUSCA

This dissertation and three earlier papers (Corgan, 1965; Barrelle, 1963; Richards, 1954) record 186 molluscan species from the Mudlump Province. They are here listed alphabetically and distribution is graphically shown. Footnotes and the Material Studied section of the text discuss individual collections.

Species listed constitute about one-half of the total fauna present in available collections from the Mudlump Province. Few molluscan faunas are this well known.

Harry (1942), Johnson (1934), Parker (1956; 1960), and Rehder (1954) are principal sources of bathymetric data but the entire content of "Johnsonia" and "the Nautilus" was examined.

CLASS PELECYPODA	Depth	Richards (1954)		Barrelle (1963)				Corgan (1965) and Present Report							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Aequipecten concentricus								X							X
Aequipecten gibbus				X	X			X							
Aequipecten glyptus	69-156														x
Aequipecten muscosus	1-90				X	X	X								
Anadara lienosa															X
[Anadara notablis[1,15]]			X												
Anadara ovalis								X							
[Anadara transversa[1,15]]		X													
Anomia simplex	0-12			X	X	X	X		X	X	X	X			X
Antigona stringilliana	40-70								X	X	X				X
[Arcopsis adamsi[1,15]]		X													
Barbatia dominguensis	10-60			X	X	X									
Callocardia texasiana					X	X	X								
Cardiomya ornatissima[15]	2-124				X		X			X					

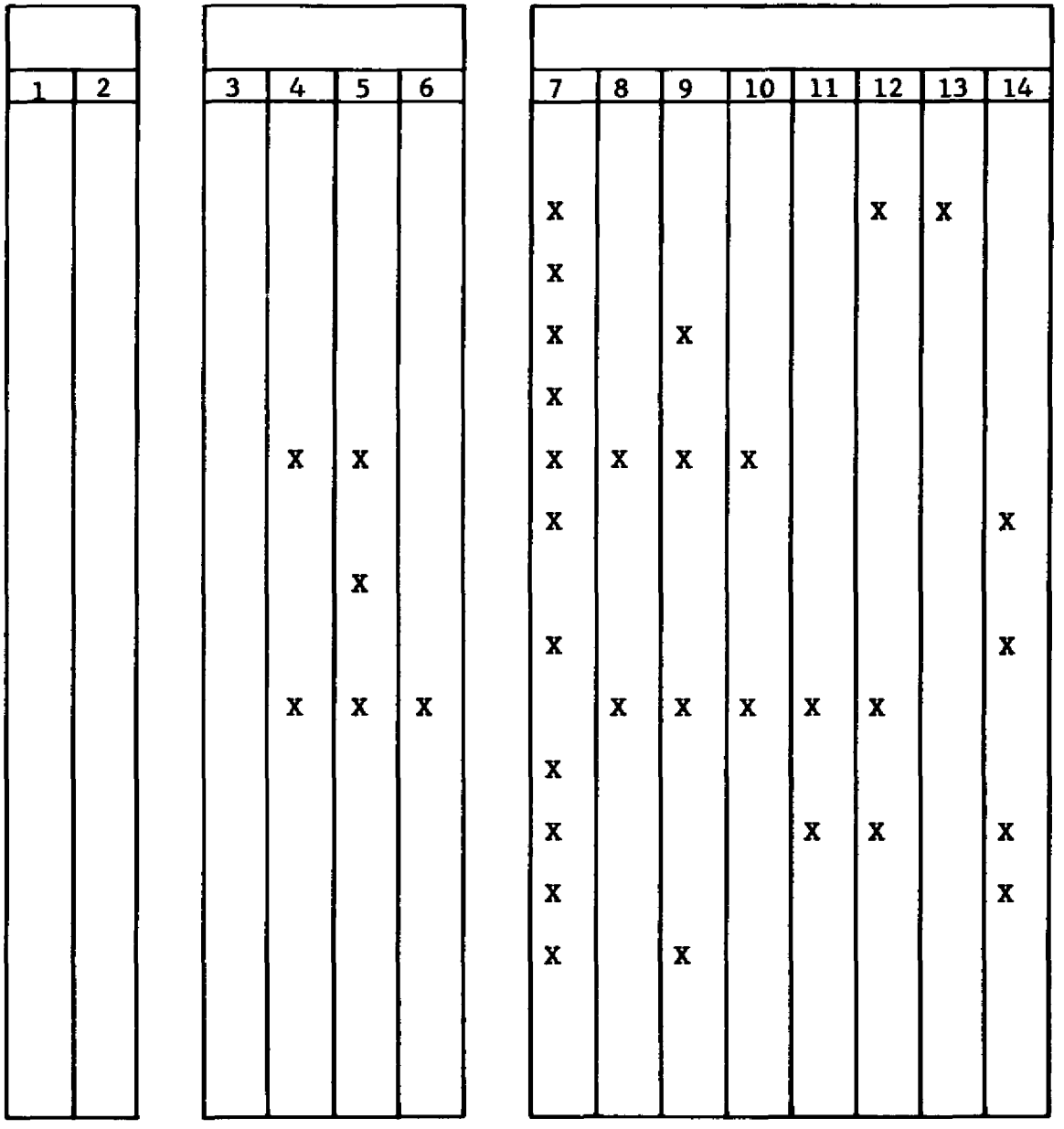
	Depth	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Cardita floridana					X										
Caryocorbula cubaniana	3-6							X	X	X	X	X			X
Chama congregata	1-52				X					X					
[Chione cancellata[1]]		X													
Chione clenchi	6-35			X		X	X	X							
Chione latilirata	10-124				X	X									
Chione paphia									X	X					
Chlamys benedicti	25-72														X
[Corbula contracta[1]]	3-63	X													
Crassinella lunulata	1-60			X	X	X	X	X	X	X	X	X			X
Crassostrea virginica															X
Cuspidaria granulata	3-100				X	X									
Cuspidaria jeffreysi	193-687														
Dinocardium robustum[15,16]		X	X												

	Depth	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Echinochama cornuta	3-60				X					X	X				X
Eucrassatella speciosa	3-100														X
Gouldia cerina	1-95			X	X	X	X								
Laevicardium laevigatum	1-75				X										X
Laevicardium mortoni	1-2				X										
Lima tenera	0-65			X	X		X								
Macoma tageliformis[17]	2-11							X							
[Mulinia lateralis[1]]		X													
Nucula aegeensis	5-464									X					
Nucula proxima	11-35				X	X	X	X	X	X	X	X			X
Nuculana acuta	7-225	X	X		X	X		X		X	X	X			X
Nuculana carpenteri	10-487			X	X										
Nuculana concentrica	1-35							X							X
Pandora bushiana	1-127							X							

	Depth	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Papyridea soleniformis					X					X					X
Pecten laurenti															X
Pecten papyraceous	30-45			X	X	X	X								
[Phacoides amianthus[1]]		X													
Phylloda squamifera	0-85			X	X	X									
Pinctada radiata	0-2														X
Pitar cordata	20-65							X							X
Poromya granulata	15-300				X										
Poromya rostrata	40-100			X	X	X									
Quadrans lintea	1/2-35				X	X	X								
Solecurtus cumingianus	4-111				X										
Semele bellastriata															X
[Tellina alternata[1]]		X													
Varicorbula operculata	12-250			X	X	X	X								

	Depth	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Verticordia fischeriana	10-60				X										
Verticordia ornata	5-200				X	X	X	X		X	X	X			X
Yoldia solenoides	40-118	X	X	X	X	X	X	X	X	X	X	X			X
CLASS SCAPHOPODA															
Cadulus acus ?	25-244	X	X					X						X	
Cadulus anderseni[18]								X							
Cadulus cheethami[18]								X			X				
Cadulus hilgardi[18]											X		X		
Cadulus howei[18]								X		X					
Cadulus louisianae[18]								X							
Cadulus morgani[18]													X	X	
Dentalium sp. A								X	X	X					
Dentalium ex gr. D. ceratum[18]									X	X	X			X	X

	Depth	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Dentalium aff. D. laqueatum			X							X	X		X	X	X
Fustiaria perlonga								X						X	
Fustiaria aff. F. sowerbyi								X						X	
CLASS GASTROPODA															
Alabina cerithidioides								X	X	X	X				X
Alvinia auberiana										X				X	
Anachis avara					X	X	X								
Anachis catenata								X							
Ancistrosyrinx radiata	25-640							X							
Antillophos candei	20-180							X							
Aorotrema nicholsi[18]											X			X	X
Architectonica nobilis	0-12+														X
Arene lis[18]								X	X	X			X		X

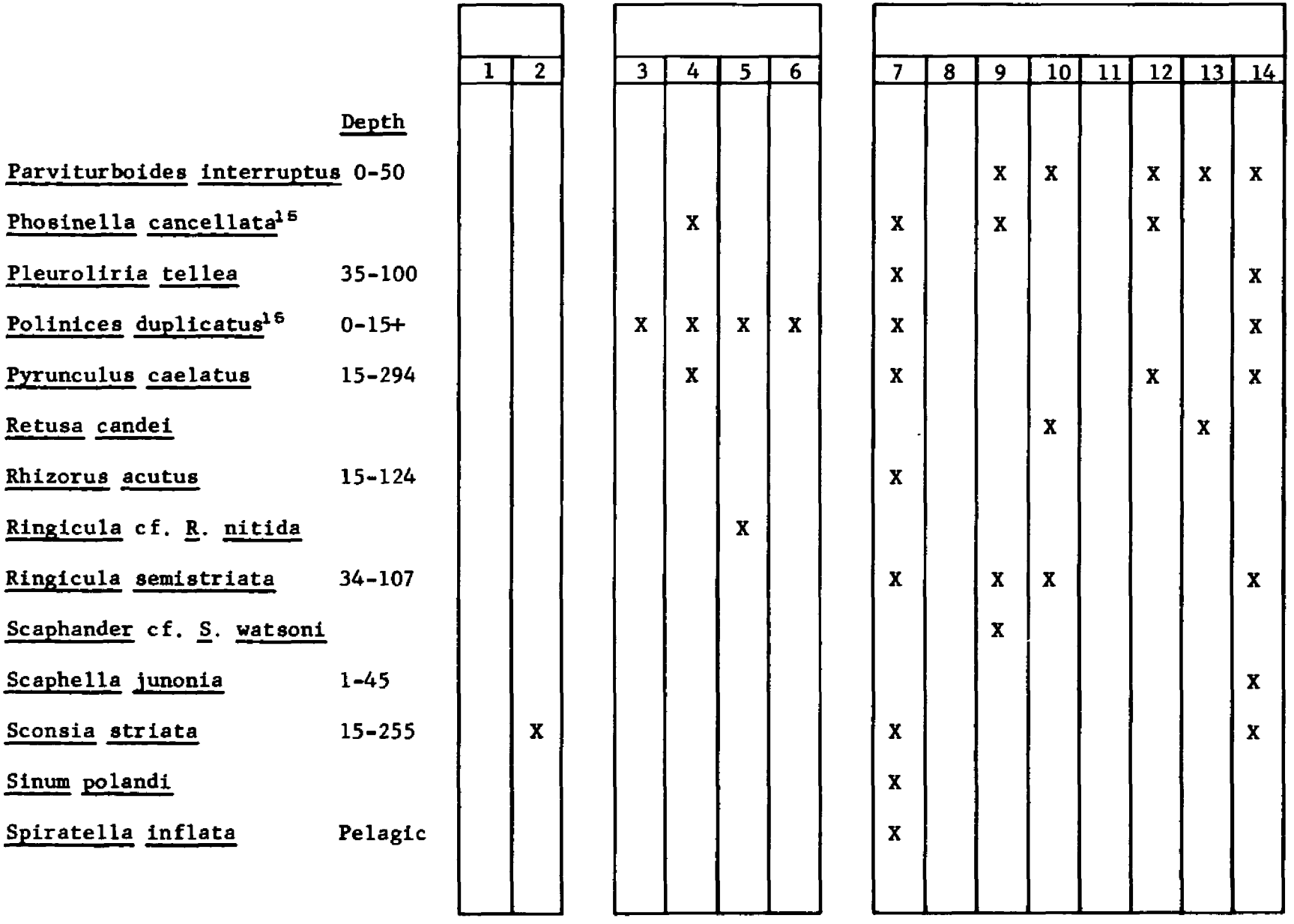


	Depth	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Atlanta peroni	Pelagic							X					X	X	
Atys lineata								X							
Atys riiseana, new subspecies[15]								X		X					
Aurinia schmitti	60-80							X							
Balcis intermedia[15]	4-440				X	X		X	X	X	X				
Besla varia[18]								X							X
Bulla striata						X									
Busycon sinistrum								X							X
Calyptraea centralis	6-52				X	X	X		X	X	X	X	X		
Cavolina inflexa	Pelagic							X							
Cavolina longirostris	Pelagic							X				X	X		X
Cavolina quadridentata	Pelagic							X							X
Cavolina trispinosa	Pelagic							X		X					

	Depth	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Cavolina uncinata	Pelagic													X	
Cerapons simulator[18]										X	X		X	X	
Cerithiopsis emersoni[15]	1-33				X					X					
Cerithiopsis greeni	3-10				X										
Cerodrillia perryae					X	X	X								
Chrysallida gaudens[18]														X	
Circulus pentagonus[15]	3-17					X	X	X		X	X			X	X
Clathrodrillia ostrearum	1-90							X							
Clio polita	Pelagic							X							
Clio pyramidata	Pelagic							X							
Conus clarki	25-65														X
Conus stimpsoni	4-80														X
Crepidula fornicata		X			X	X	X			X	X	X	X		X
Crepidula plana						X							X		X

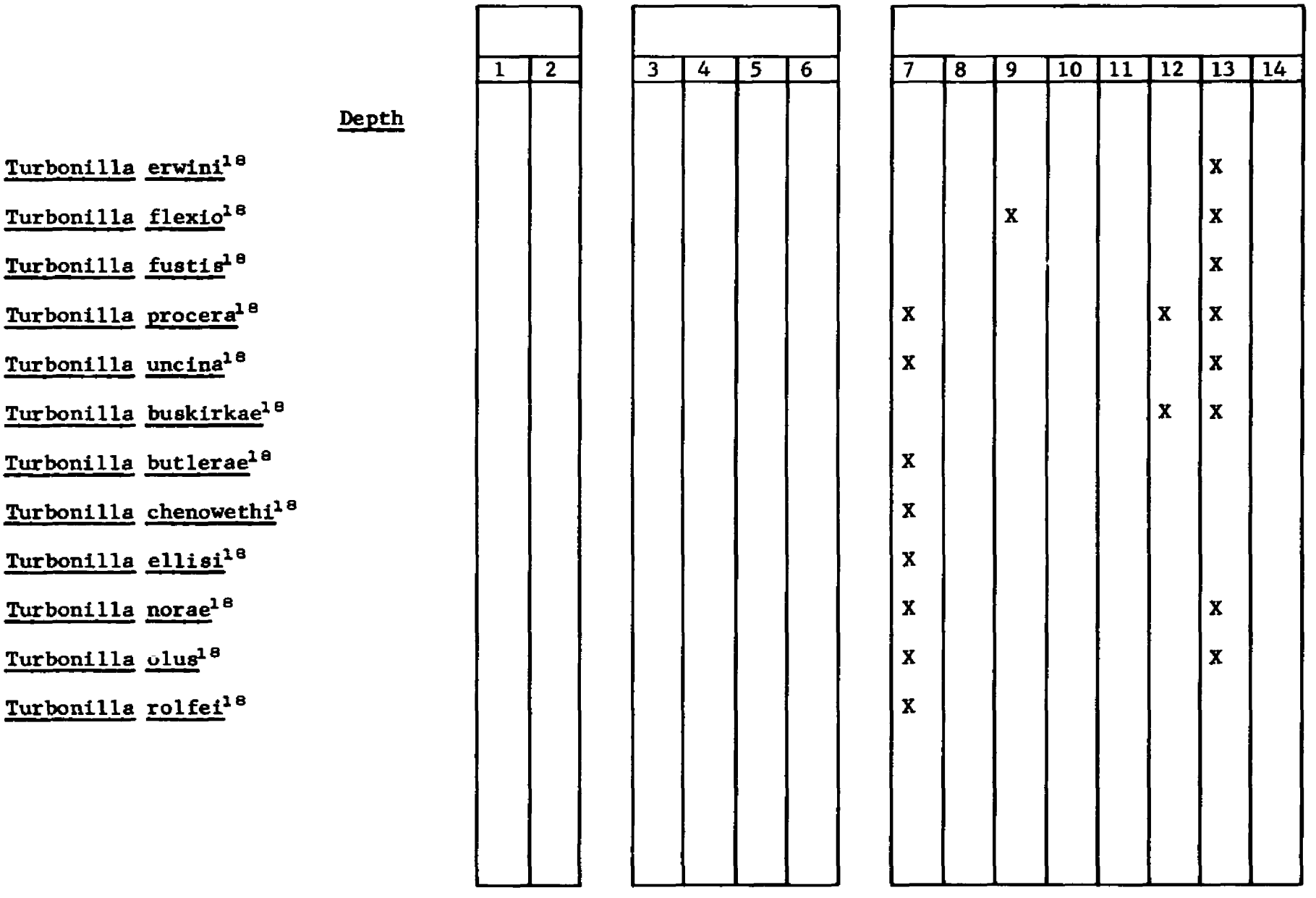
	Depth	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Creseis acicula	Pelagic													X	
Creseis virgula	Pelagic													X	
Crucibulum auricula	15-100									X					X
Crucibulum striatum	3-189				X										
Cylindriscala cf. C. tortilis								X							
Cymatium krebsi	14-18														X
Daphnella elata	15-22										X				
Diodora cayenensis	0-19														X
Distorsio mcgintyi	25-170														X
Elephantanellum imbricatum														X	
Episcynia inornata	5-42														X
Epitonium candeanum					X	X									
Epitonium cf. E. tollini				X											
Eulima bifasciata								X							X
Eulimastoma vetula[18]								X						X	

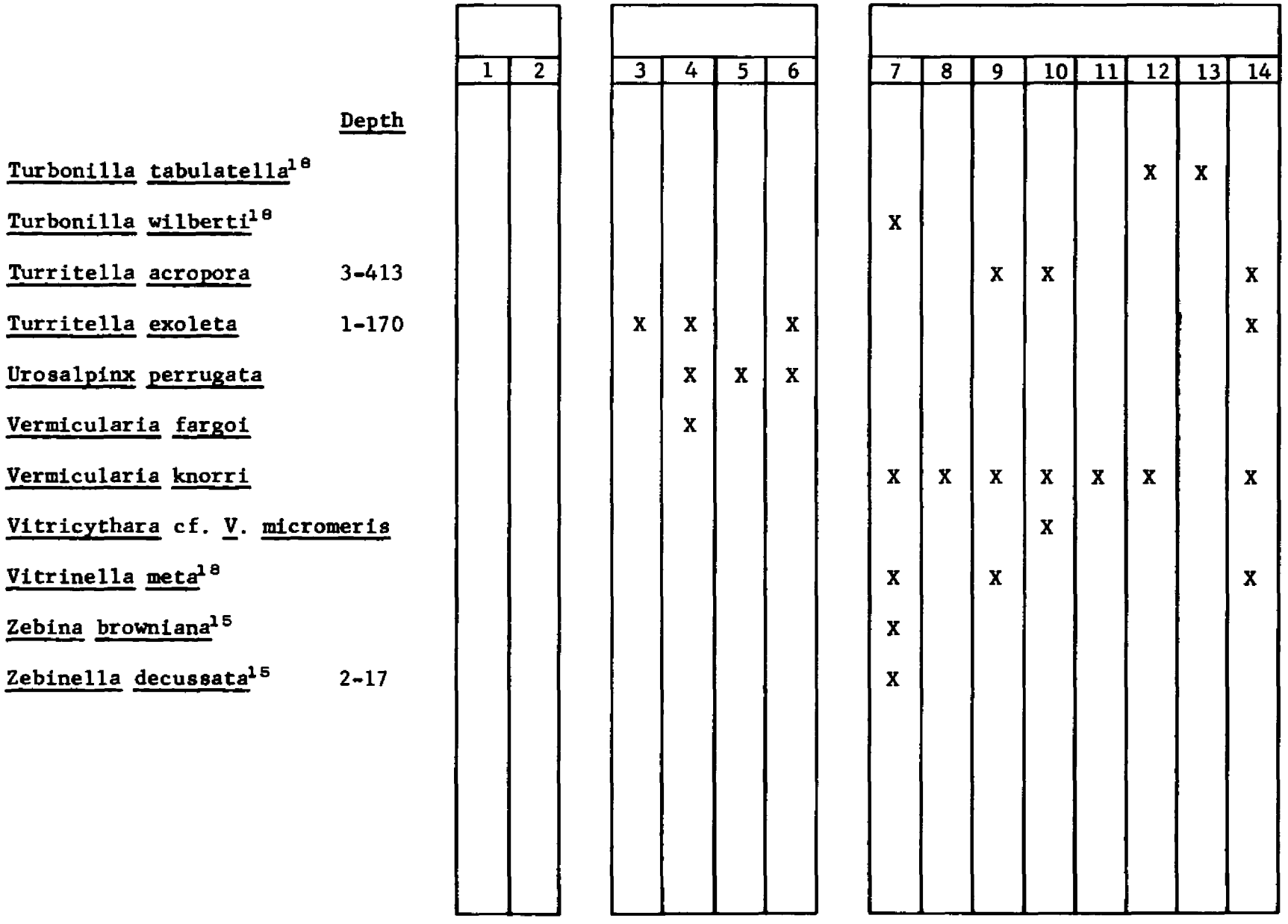
	Depth	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Fasciolaria lilium	15-30							X							X
Fusinus encosmius	27-111														X
Ithycythara lanceolata								X		X	X				X
Kilatus pondella[18]								X							
Litiopa melanostoma	Pelagic							X							X
Longchaeus candidus	15-200							X							
Marginella denticulata	1-600							X		X	X				X
Micranellum regulare														X	
Murex fulvescens	4-35														X
Murex messorius	5-80														X
Nassarius albus[15]	1-191			X	X	X	X	X	X	X	X	X	X		X
Natica canrena	40-65														X
Niso interrupta	10-+100							X							
Olivella mutica					X	X	X								



	Depth	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Parviturboides interruptus	0-50									X	X		X	X	X
Phosinella cancellata[15]					X			X		X			X		
Pleuroliria tellea	35-100							X							X
Polinices duplicatus[16]	0-15+			X	X	X	X	X							X
Pyrunculus caelatus	15-294				X			X					X		X
Retusa candei											X			X	
Rhizorus acutus	15-124							X							
Ringicula cf. R. nitida						X									
Ringicula semistriata	34-107							X		X	X				X
Scaphander cf. S. watsoni										X					
Scaphella junonia	1-45														X
Sconsia striata	15-255		X					X							X
Sinum polandi								X							
Spiratella inflata	Pelagic							X							

	Depth	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Strombus alatus	12-35							X							X
Syrnola ampla[18]								X							
Syrnola meridiana[18]								X							
Terebra dislocata	0-20														X
[*Terebra protexta*[1]]		X													
Tonna galea	12-35														X
Trivia maltbiana	2-50														X
Turbonilla apiculata[18]														X	
Turbonilla asperella[18]														X	
Turbonilla baca[18]								X							
Turbonilla conferta[18]								X					X	X	
Turbonilla confinium[18]								X			X			X	
Turbonilla heathae[18]								X							


Depth
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Turbonilla erwini[18]
Turbonilla flexio[18]
Turbonilla fustis[18]
Turbonilla procera[18]
Turbonilla uncina[18]
Turbonilla buskirkae[18]
Turbonilla butlerae[18]
Turbonilla chenowethi[18]
Turbonilla ellisi[18]
Turbonilla norae[18]
Turbonilla olus[18]
Turbonilla rolfei[18]


Depth
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Turbonilla tabulatella[18]
Turbonilla wilberti[18]
Turritella acropora 3-413
Turritella exoleta 1-170
Urosalpinx perrugata
Vermicularia fargoi
Vermicularia knorri
Vitricythara cf. V. micromeris
Vitrinella meta[18]
Zebina browniana[15]
Zebinella decussata[15] 2-17

[1]Fauna from a well at Burwood, Louisiana. This well was drilled by the U.S. Army Corps of Engineers and samples were examined by Richards (1954) to a depth of 625 feet. This well should have penetrated the mudlump clays that are exposed in the mudlumps of Southwest Pass, a few miles away (Morgan, 1961, pl. 1). Cuttings are predominantly from rather shallow depths. Since most species do not recur in other mudlump faunas, records from the Burwood well are here questioned.

[2]Fauna from a mudlump island in the mouth of Pass a Loutre. This is probably the same as the PAL 7 locality of this dissertation, comparability is further discussed in text description of material studied.

[3]The -8.25 to 8.38 foot interval in SP 1-B. Further records from this interval are given in column 8. In Barrelle's study (Barrelle, 1963) pelecypods received greater relative emphasis than they did in Corgan (1965). Neither Barrelle (1963) nor Corgan (1965) provides complete faunal lists. They studied the same collection but Barrelle's study did not produce a labeled collection and Corgan's was not oriented toward an exhaustive listing of the fauna.

[4]The -348.8 to 352' interval in SP 1-B. Further records are given in column 9.

[5]The -455.7 to 455.9' interval in SP 1-B. See note number 10, below.

[6]The -472.8 to 473.0' interval in SP 1-B. Further records are given in column 11.

[7]Fauna from PAL 7. Most probably equals column 2. See discussion

in the Material Studied section of the text.

[8]The -8.2 to 8.4' interval in SP 1-B. Equals column 3.

[9]The -348.8 to 352' interval in SP 1-B. Equals column 4.

[10]The -455.41 to 456.75' interval and a -453.6' core chip from SP 1-B. See note number 5, above.

[11]The -472.8 to 473.0' interval in SP 1-B. See column 6, above.

[12]SP 5, see Materials Studied section or the text.

[13]SP 6, see Materials Studied section or the text.

[14]SP 94, see Materials Studied section or the text.

[15]In one or more references, this species is recorded in a different generic combination or under a synonymous name.

[16]Records from the Burwood well are questioned. This species may not be part of the mudlump fauna.

[17]Identified by Dr. Kenneth J. Boss, Museum of Comparative Zoology.

[18]A new species described in this report.

Appendix 2

LOUISIANA STATE UNIVERSITY DEPARTMENT OF GEOLOGY MUSEUM TYPE COLLECTION NUMBERS

All specimens treated in the Systematic Descriptions are deposited in the Louisiana State University Department of Geology Museum Type Collection and are assigned collection numbers as indicated below. An asterisk (*) indicates a figured specimen. Numbers in parentheses () show abundance.

Alvinia auberiana (Orbigny), 1841. 7342*, 7480 (7).

Aorotrema nicholsi Corgan, new species. Holotype 7377*. Paratypes 7375 (1), 7376 (1).

Arene lis Corgan, new species. Holotype 7359*. Paratypes 7360*, 7361*, 7362 (5), 7363 (1), 7364 (2), 7365 (2).

Besla varia Corgan, new species. Holotype 7352*. Paratypes 7354*, 7353*, 7355 (24), 7351 (8), 7392*.

Cadulus acus Dall, 1889? 7366*, 7476 (19), 7477 (13).

Cadulus cheethami Corgan, new species. Holotype 7471*. Paratypes 7464*, 7465* (thin-sections), 7468*, 7469*, 7470*, 7462 (8), 7467 (+1,280).

Cadulus anderseni Corgan, new species. Holotype 7378*. Paratypes 7379*, 7380 (11), 7463 (Transverse thin-section).

Cadulus morgani Corgan, new species. Holotype 7455*. Paratypes 7453 (2), 7454 (1).

Cadulus hilgardi Corgan, new species. Holotype 7456*. Paratypes 7457*, 7458 (2), 7459 (5), 7460 (12), 7461 (21).

Cadulus howei Corgan, new species. Holotype 7451*. Paratypes 7452*, 7448 (1), 7449 (8), 7450 (46), 7466 (Axial thin-section).

Cadulus louisianae Corgan, new species. Holotype 7339.

Cerapons simulator Corgan, new species. Holotype 7387*. Paratypes 7388*, 7389 (1), 7390 (1), 7391 (1).

Chrysallida Species A. 7429*.

Chrysallida Species B. 7428*, 7427.

Chrysallida Species C. 7426*.

Chrysallida gaudens Corgan, new species. Holotype 7344*. Paratypes 7345 (7).

Circulus pentagonus (Gabb), 1873. 7382*, 7383*, 7485 (1), 7486 (2), 7487 (1), 7488 (2).

Elephantanellum imbricatum (Carpenter), 1859. 7430*, 7482 (16).

Episcynia inornata (Orbigny), 1841. 7343*, 7479 (1).

Eulimastoma vetula Corgan, new species. Holotype 7348*. Paratypes 7346*, 7347 (20), 7349*.

Eulimastoma Species A. 7425*, 7424 (3), 7423 (6).

Kilatus pondella Corgan, new species. Holotype 7350*.

Longchaeus candidus (Moerch), 1875. 7356*, 7478 (4).

Micranellum regulare (Carpenter), 1859. 7341*, 7481 (48).

Parviturboides interruptus (C. B. Adams), 1850. 7381*, 7489 (56), 7490 (3), 7491 (2), 7492 (6), 7493 (2).

Phosinella cancellata (Philippi), 1847. 7373*, 7475 (1), 7494 (1), 7495 (5).

Syrnola ampla Corgan, new species. Holotype 7396*. Paratypes 7397 (3).

Syrnola meridiana Corgan, new species. Holotype 7357*.

Turbonilla (Turbonilla) apiculata Corgan, new species. Holotype 7437*. Paratypes 7438 (4).

Turbonilla (Turbonilla) asperella Corgan, new species. Holotype 7393*.

Turbonilla (Turbonilla) baca Corgan, new species. Holotype 7367*. Paratype 7368.

Turbonilla (Turbonilla) conferta Corgan, new species. Holotype 7420*. Paratypes 7418*, 7419*, 7421 (7), 7422 (2).

Turbonilla (Turbonilla) confinium Corgan, new species. Holotype 7406*. Paratypes 7407 (25), 7408 (1), 7409 (2).

Turbonilla (Turbonilla) erwini Corgan, new species. Holotype 7358*.

Turbonilla (Turbonilla) flexio Corgan, new species. Holotype 7440*. Paratypes 7441*, 7439 (1), 7442 (9).

Turbonilla (Turbonilla) fustis Corgan, new species. Holotype 7398*. 7445*, 7446 (4).

Turbonilla (Turbonilla) heathae Corgan, new species. Holotype 7402*.

Turbonilla (Turbonilla) procera Corgan, new species. Holotype 7413*. Paratypes 7410*, 7414*, 7411 (1), 7412 (1) 7415 (40), 7416 (1), 7417 (1).

Turbonilla (Turbonilla) uncina Corgan, new species. Holotype 7443*. Paratypes 7444*, 7447 (36).

Turbonilla (Pyrgiscus) buskirkae Corgan, new species. Holotype 7401*. Paratype 7369*.

Turbonilla (Pyrgiscus) butlerae Corgan, new species. Holotype 7404*.

Turbonilla (Pyrgiscus) chenowethi Corgan, new species. Holotype 7405*.

Turbonilla (Pyrgiscus) ellisi Corgan, new species. Holotype 7400*. Paratype 7399.

Turbonilla (Pyrgiscus) norae Corgan, new species. Holotype 7403*, 7433*.

Turbonilla (Pyrgiscus) olus Corgan, new species. Holotype 7432*. Paratypes 7430 (9), 7431 (4).

Turbonilla (Pyrgiscus) rolfei Corgan, new species. Holotype 7370*. Paratype 7371.

Turbonilla (Pyrgiscus) tabulatella Corgan, new species. Holotype 7435*. Paratypes 7436 (18), 7434 (1).

Turbonilla (Pyrgiscus) wilberti Corgan, new species. Holotype 7394*. Paratype 7395.

Vitrinella meta Corgan, new species. Holotype 7384*. Paratypes 7385 (2), 7386 (2).

Zebina browniana (Orbigny), 1841. 7374*.

Zebina decussata (Montagu), 1803. 7372*.

Appendix 3

REDESCRIPTION OF SOME WESTERN ATLANTIC *CADULUS*

One of the largest and the three smallest *Gadila*-like Western Atlantic *Cadulus* are not unequivocally identifiable from published data. They are redescribed below. Descriptions are based on examination of type specimens.

Cadulus (*Gadila*) *greenlawi* Henderson, 1920

1920. *Cadulus* (*Platyschides*) *greenlawi* HENDERSON, U.S. Nat. Mus. Bull. 111, p. 123-124, pl. 18, fig. 11.

Redescription.- *Cadulus* (*Gadila*) of large size; opacity bands moderate, persistent throughout ontogeny; growth form elongate, curvature strong, expansion slight; inflation at or near anterior third; aperture and adult shell with fairly strong dorso-ventral compression; holotype 11 mm long, 1.00 x 1.25 mm wide, with a .25 mm apical diameter.

Remarks.- Known only from the holotype, USNM 314767. Henderson (1920, p. 123) knew the apex was *Gadila*-like, but placed *C. greenlawi* in *Polyschides* because it was much larger than any Western Atlantic *Gadila*. Larger *Gadila* are known.

Cadulus (Gadila) minusculus Dall, 1889

Plate IV, Figure 6

1889. Cadulus minusculus DALL, Bull. Mus. Comp. Zool. Harvard Univ., v. 18, p. 432.

1889. Cadulus minusculus Dall: DALL, U.S. Nat. Mus. Bull. 37, p. 78.

1898. Cadulus (Gadila) minusculus Dall: PILSBRY AND SHARP, Tryon's Man. Conch., v. 17, p. 164, pl. 32, figs. 42-43.

1901. Not Cadulus minusculus Dall: DALL AND SIMPSON, Bull. U.S. Fish Comm. 1900, p. 457.

1903. Cadulus minusculus Dall: DALL, U.S. Nat. Mus. Bull. 37, 2nd ed., p. 78.

1920. Cadulus minusculus Dall: HENDERSON, U.S. Nat. Mus. Bull. 111, p. 134, pl. 19, fig. 4.

Redescription.- Cadulus (Gadila) of very small size; fusiform, slightly curved, with moderate, medial inflation; aperture oblique, with slight dorso-ventral compression; apex round, small, with internal callosity; holotype 2.2 mm long, about .60 mm in diameter, internal diameter of aperture about .38 x .35 mm, diameter of apex, within callosity, about .25 mm, callosity about .05 mm.

Remarks.- This species seems much more compressed than measurements indicate. The lectotype designated by Henderson is USNM 93122.

Cadulus (Gadila) iota Henderson, 1920

Plate IV, Figure 5

1920. Cadulus (Gadila) iota HENDERSON, U.S. Nat. Mus. Bull. 111, p. 134-135, pl. 19, fig. 2.

Redescription.- Cadulus (Gadila) of very small size; without significant curvature or compression; inflation medial; aperture oblique; apex round, with internal callosity; size, about 2.35 mm in length, with a .50 mm diameter, aperture .30 mm, apex about .15 mm within the callosity, callosity near .05 mm.

Remarks.- The apical portion of the holotype, USNM 161581, is broken. Henderson's description notes that C. iota is smaller than C. minisculus. This is not true. Henderson took inaccurate measurements of C. minusculus from a prior description, and he apparently compared types after the type of C. iota had been broken.

Cadulus nanus Clench and Aguayo, 1939

Plate IV, Figures 7-8

1939. Cadulus (Gadila) iota nanus CLENCH AND AGUAYO, Mem. Soc. Cubana Hist. Nat., v. 13, p. 197.

Redescription.- Cadulus of minute size; with slight inflation just anterior to middle; very slightly curved; apex strongly compressed dorso-ventrally, aperture slightly compressed laterally; without internal apical callosity; without sculpture; size of only known specimen, 1.8 mm in length and .5 mm in width, apex .18 x .26 mm, aperture .30 x .27 mm.

Remarks.- The holotype, MCZ 8922, and a paratype in Cuba's Museo Poey are the only known specimens. The species has never been illustrated.

Very small Cadulus with dorso-ventrally compressed apices and laterally compressed apertures appear to form a very distinct morphologic group. Reference to Cadulus (Gadila) does not seem proper.

Appendix 4

REFERENCE SPECIMENS EXAMINED IN STUDIES OF PROSOBRANCHS

REGISTER OF TYPE AND REFERENCE SPECIMENS EXAMINED IN STUDY OF AOROTREMA

Cyclostrema cistronium Dall

Holotype: USNM 94581. Recent Western Atlantic lots: USFC 92802, USNM 95083, 95084, 95088. Pliocene, Florida: ANSP 18442, 18445.

Aorotrema gardnerae Pilsbry

Holotype: ANSP 19550.

Cyclostremiscus humboldti Hertlein and Strong

Paratype: ANSP 188328.

Cyclostrema pontogenes Schwengel and McGinty

Holotype: ANSP 178720.

REGISTER OF TYPE AND REFERENCE SPECIMENS EXAMINED IN STUDY OF CIRCULUS PENTAGONUS (GABB)

Circulus cosmius Bartsch

Holotype, Recent: USNM 192708.

Cyclostremiscus glyptobasis Pilsbry and Olsson

Holotype, Recent: 187832. Paratypes (3): 277268. Paratypes (3): F 93 in the Olsson collection, donated to the Academy of Natural Science of Philadelphia but not yet assigned accession numbers.

Cyclostremiscus glyptomphalus Pilsbry and Olsson

Holotype and 3 paratypes: ANSP 187831.

Skenea trilix Bush

Recent lots: USNM 32496 (7), 35365 (15), 35365 (1. This lot bears the same number as the preceding. The USNM-USFC label is marked TYPE in pencil but the specimen is not in the type collection), 35395 (7), 35827 (24), 40579 (17), 40660 (16), 40806 (1), 40817 (26), 40888 (3), 41444 (5), 44622 (13), 44661 (8), 45160 (1), 45161 (7), 45162 (1), 53864 (10), 941916 (4), 94917 (1), 94923 (1), 94924 (2), 198170 (22), 322707 (1), 406713 (3), 406714 (1), 449157 (17).

REGISTER OF TYPE AND REFERENCE SPECIMENS

EXAMINED IN STUDY OF EPISCYNIA

Episcynia bolivari Pilsbry and Olsson

The holotype is supposed to be in the collection of the Academy of Natural Sciences of Philadelphia but could not be located.

Adeorbis carinata Gabb

Holotype, Miocene: ANSP 2832.

Episcynia mauryi Gardner

Holotype, Miocene: USNM 350510.

Episcynia megalia Woodring

Holotype, Miocene: USNM 561325.

Vitrinella multicarinata Dall

Pliocene Western Atlantic lots: ANSP 18433 (1 specimen, Florida), 18443 (7 specimens, Florida), 18482 (14 specimens). Recent Western Atlantic lots: USNM 449160 (1 specimen), 594170 (1 specimen); ANSP 228515 (number not recorded), 277550 (1 specimen), 277551 (3 specimens).

REGISTER OF TYPE AND REFERENCE SPECIMENS EXAMINED IN STUDY OF PARVITURBOIDES

Parviturboides avitus Pilsbry

Cotypes, Pliocene, Florida: ANSP 18460.

Fossarus (Gottoina) bella Dall

Recent Western Atlantic specimen: ANSP 178759.

Parviturbo decussatus clausus Pilsbry and Olsson

Cotypes, Recent, Eastern Pacific: ANSP 181281. Additional Recent East Pacific lot: ANSP 277273 (3 specimens).

Fossarus comptus Woodring

Holotype: Middle Miocene, Antilles: USNM 369501. Recent Western Atlantic lots: USNM 656175; ANSP 264794 (2 specimens); 291462; 297005 (4 specimens); 297548 (2 specimens).

Parviturbo copiosus Pilsbry and Olsson

Syntypes (4) Recent Eastern Pacific: ANSP 181270. Other Recent Eastern Pacific lots: ANSP 277274 (18 specimens), 277275 (1 specimen).

? Vitrinella decussata Carpenter

Paratype ?, Recent Eastern Pacific: ANSP 20602. This specimen bears an old label from the Smithsonian Mazatlan Collection and apparently is one of Carpenter's original specimens.

Parviturbo germanus Pilsbry and Olsson

Holotype, Recent: ANSP 181282.

Vitrinella interrupta C. B. Adams

Recent Western Atlantic lots: USNM 64361 (number not recorded), ANSP 199916 (11). Pilsbry (1946, p. 5) apparently had access to type material but this could not be located in collections examined.

Liotia (Arene ?) milium Dall

Holotype, Pliocene, Western Atlantic, USNM 113085. Western Atlantic Recent lots: ANSP 264794 (3), 291246 (1), 297548 (2).

Vitrinella monile Carpenter

Paratype ?, Recent: ANSP 20603. This specimen is from the Smithsonian Mazatlan Collection and appears to be one of Carpenter's specimens.

Cyclostrema sanibelense Pilsbry

Holotype, Recent Western Atlantic, ANSP 181119. Paratypes: USNM 617402, ANSP 181119A (4), 174896 (7). Other Recent Western Atlantic lots: ANSP 154841 (1), 178549 (10), 181078 (4), 185343 (26), 220894 (5), 277482 (1), 287483 (2).

Delphinula tuberculosa Orbigny

Western Atlantic Recent lots: ANSP 20620 (6), 46134 (2), 70147 (1, broken), 130709 (1).

Cyclostrema zacalles Mazyck

Cotypes, Recent, Western Atlantic, USNM 251242. The lot also includes a prepared radula.

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EXAMINATION AND THESIS REPORT

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Major Field: Geology

Title of Thesis: Quaternary Micromolluscan Fauna of the Mudlump Province, Mississippi River Delta.

Approved:

Allan H. Cha
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